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THE ANCIENT MAMMALS OF BRITAIN.

I.—The Cavern and Brick-Earth Period.

By R. Lydekker, B.A.Cantab., F.R.S.

OWING to various circumstances, among which denudation not improbably occupies a place, during the Tertiary period the geological record in Britain is far more imperfect than usual, owing to the total absence in our islands of all traces of strata corresponding to the typical Miocene deposits of the Continent. Nevertheless, in spite of this imperfection, and the consequent absence of the remains of the species which lived during the missing epoch, Britain is remarkably rich in fossil mammals, our caves, brick-earths, and river-gravels having preserved the bones and teeth of the later forms in almost endless profusion; while the so-called forest-bed and crags of the eastern coast are rich in those of a somewhat earlier epoch; and the deposits of the Hampshire and London basins have yielded evidence of the mammalian life of the lower portions of the Tertiary period. In some respects it is fortunate that we have not the hosts of Tertiary mammals found on the Continent, as if so, it would be absolutely impossible to give any adequate account of them within the limits at our disposal; but as things are, the list of species is of manageable proportions.

In giving a brief sketch of the ancient British mammals, we shall practically omit mention of those found in the most superficial deposits, such as the fens and turbaries, since the majority of these belong to species which are either still living in the country, or are existing in other parts of Europe. Our regular survey will, therefore, commence with the mammals found in the caverns and the various more or less nearly contemporary brick-earths and gravels, which generally form high-level plateaux in our river valleys, and are for the most part of more recent date than the epoch of maximum extension of the ice of the glacial period. The whole of these deposits belong to the Pleistocene, or latest geological period; and the next in point of age are the formations exposed on the east coast of England in the counties of Norfolk, Suffolk, and Essex. The highest of those deposits to which we shall specially refer is the series usually denominated the forest-bed, so called on account of the relics of an ancient forest which it contains *in situ*. Although clearly antedating the glacial epoch, there is some doubt as to the precise geological age of this deposit, some authorities referring it to the top of the Pliocene period, while others consider that it forms the base of the Pleistocene. As the majority of the mammalian remains yielded by this bed belong to existing species, the latter view is the one which we feel inclined to adopt. Below the forest-bed come the crags, of which the Norwich crag belongs to the upper portion of the Pliocene period, while the Red and Coralline crags may be assigned to the lower division of the Pliocene. The tertiaries of the Hampshire and London basins belong solely to the Oligocene and Eocene epochs; and the mention of the ages of these different horizons may accordingly be reserved till we come to the consideration of their fauna.

With regard to the epoch of our caverns and brick-earths, it may be observed, in the first place, that by far the great majority of the species whose remains are entombed in the various deposits are still existing, although most of the larger ones have disappeared from Britain, either from having been destroyed by human agency, or because the climate became unsuitable to them. Of such existing species we shall only make mention when there is something of special interest connected with them, and the reader will therefore understand that we have no intention of attempting anything like a complete list of the mammalian fauna of this epoch. The most remarkable feature connected with this fauna is the apparently contradictory evidence which it affords as to the nature of the climate then prevalent. The glutton, reindeer, Arctic fox, and musk-ox are strongly indicative of a more or less Arctic climate; many of the voles (*Microtus*), picas (*Lagomys*), and susliks (*Spermophilus*), together with the saiga antelope, appear to point equally strongly to the prevalence of a steppe-like condition; while the hippopotamus and spotted hyæna seem as much in favour of a sub-tropical state of things. Many attempts have been made to reconcile these apparently contradictory circumstances; one of the older views being that while the tropical types of animals lived during a warm interlude, they migrated southwards with the incoming of colder conditions to the Arctic type of fauna. Since, however, it has now been ascertained that the remains of both tropical and Arctic forms have been found lying side by side in the same bed, it is perfectly certain that such an explanation will not meet the exigencies of the case. We have, however, yet much to learn about the effects of climate on animals—our experience being, unfortunately, confined to a single epoch; and the fauna of the highlands of Tibet shows that many types of animals formerly regarded as more or less essentially tropical can withstand a winter climate of extreme severity.

Among the forms that at first sight seem to indicate that Britain enjoyed a mild climate during the deposition of the brick-earths of the Thames valley is a monkey, more or less closely allied to the existing macaques

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(*Macacus*), but, unfortunately, only known to us by a small fragment of the upper jaw containing a single tooth, which was obtained many years ago from the brick-earth of Grays, in Essex. Although the majority of the macaques, together with their allies the langurs, are inhabitants of warm regions, it must not be forgotten that a representative of each is found in Tibet, where the winter cold is intense. This species is the only evidence yet known of the occurrence of monkeys in Britain.

Passing by the bats and insectivores, as pertaining exclusively to existing species, we proceed to the carnivores. Among these, the rarest is a species of sabre-toothed tiger (*Machærodus latidens*), of which specimens of the enormous serrated upper tusks have been obtained from Kent's Hole, near Torquay. These sabre-tooths were widely distributed during the Pleistocene and Pliocene epochs, having been discovered in Europe, Persia, India, and North and South America; but they seem to have been a type less adapted for persistence than the ordinary and less specialized cats. Side by side with this extinct species lived the lion, whose remains have been found, not only in most of the English caves, but likewise in many of the brick-earths and river-gravels. Although we are accustomed to regard the lion as essentially an inhabitant of the hot districts of India and Africa, it must be remembered that even in the historic period it was common in south-eastern Europe, while its near ally, the tiger, ranges northwards into Siberia, where an unusually long and thick coat protects it from the winter cold. The lynx (*Felis lynx*) and the leopard (*F. pardus*) were likewise British animals during the cavern-period; the former being to a great extent an inhabitant of northern regions. Although the great cave-hyæna was formerly regarded as extinct, it is now considered to be only a large race of the spotted African species (*Hyæna crocuta*), differing from the striped hyæna, not only by its superior size and coloration, but likewise by the structure of its teeth, the hindmost of which approximate to those of the cats. Although the present habitat of the striped hyæna is tropical or sub-tropical, there does not appear any valid reason why the creature should not have been able to withstand a comparatively cold climate. The dog tribe, as we might expect, is well represented during the Pleistocene, remains of both the fox and the wolf being common in all caverns; the latter species having, indeed, been exterminated only at a comparatively recent date in our islands. More remarkable is the occurrence of the Arctic fox (*Canis lagopus*), the remains of which have been recently identified from a fissure near Ightham, in Kent. The nearest country to Britain where this species now lives is Iceland, and it is certainly very curious to find in the same deposits remains of animals so widely separated at the present day as are the spotted hyæna and the Arctic fox. Another compatriot of the former species is the Cape hunting-dog (*Lycaon pictus*), distinguished from the wolves by the characters of the teeth and the smaller number of toes on the fore feet; and it is certainly a curious coincidence to find this genus represented by an extinct species from the Glamorganshire caverns. Passing on to the bears, we naturally expect to find the common brown bear, which was only exterminated at a late epoch of the historic period, common in the Pleistocene; and in this we are not disappointed, its remains occurring not uncommonly in the English caverns as well as in those of Ireland. A large proportion of the ursine remains found in the brick-earths of the Thames valley have, however, been assigned to the grizzly bear (*Ursus horribilis*) of North America; but as this form is distinguished from its European ally merely by slight differences in the form of the skull and teeth, we are by no means assured that this reference is well founded. Markedly distinct, however, is the gigantic cave-bear (*U. spelæus*), the skull of which may always be recognized by the sudden rise of the forehead above the eyes, while the crowns of the molar teeth display a more finely puckered structure than is to be seen in those of the existing species. This gigantic bear was one of the inhabitants of the celebrated Kirkdale cave in Yorkshire, of which spotted hyænas were, however, by far the most numerous carnivorous denizens. Much rarer than those of either bears and hyænas are the remains of the glutton (*Gulo luscus*), which have been obtained only, among the deposits now under consideration, from the caves of Banwell, Bleadon, Cresswell Crags, the Vale of Clwyd, and Yealm Bridge. The glutton is now unknown further south than Scandinavia, and in drawing any conclusions as to climate from its occurrence in Britain we must always bear in mind the comparative scarcity of the remains both of this species, the Arctic fox, and the musk-ox. It is true that the rarity of these forms is discounted by the abundance of the remains of the reindeer; but the latter are somewhat local in their distribution, being unknown to the east of London, and if the assertion that this animal still lingered in Caithness till a few centuries ago be true, no great change of climate would be necessary in order to admit of its existence in England. The other carnivores of the cavern-period are not of much importance, including species like the pine-marten, stoat, weasel, polecat, and otter, which still exist among us; although it has been thought that some bones from the Ightham fissure indicate an extinct type intermediate between the polecat and the marten.

Turning to the hoofed order, we find remains of the horse common in all the Pleistocene deposits pertaining to the cavern epoch, and from the rude yet characteristic portraits of the animal engraved by our prehistoric ancestors it would appear that the horse of this period was very similar to the wild or feral tarpan of the Russian steppes. Since the latter race, together with all the horses that have reverted to a wild condition, are inhabitants of open plains, it may be reasonably inferred that similar tracts of country formed a prominent feature in Pleistocene Britain. Although tapirs were wanting, rhinoceroses were abundant during the period in question, no less than three species having left their remains in the caverns and brick-earths, all of which resembled the existing African representatives of the genus in having two horns and no front teeth. By far the best known of these is the woolly rhinoceros (*Rhinoceros antiquitatis*), which, while closely allied to the living African Burchell's rhinoceros, differed in having its body protected from the cold by a thick coat of wool and hair. Ranging to the cold "tundras" of Siberia, where its frozen carcases are met with imbedded in the icy soil like those of the mammoth, there can be no doubt that this species was capable of withstanding a considerable degree of cold, although we may perhaps admit that the climate of Siberia during the time that these animals flourished there may have been somewhat less rigorous than at the present day. As to the difficult question of how the carcases of these rhinoceroses and mammoths became preserved in their frozen sepulchres, we prefer to leave this to those fonder of argument than ourselves. If we admit that the woolly rhinoceros could withstand a cold climate, there is no difficulty with regard to the other contemporary species, at least one of which has been met with in Siberia, although it does not appear that either was furnished with a woolly coat. Both the leptorhine (*R. leptorhinus*) and megarhine (*R. megarhinus*) rhinoceroses, as these species are termed,

differ essentially from the woolly kind by the simpler structure of their molar teeth, which are more like those of the prehensile-lipped, or so-called black rhinoceros of Africa; and the skulls and teeth of the two are so alike that it requires an expert to distinguish between them. Teeth of both species are found in the brick-earths of the Thames valley, but while those of the former are common in most of the English caves, those of the latter appear to be only known as cavern-fossils from Gower, in Glamorganshire, and from a rock-fissure near Plymouth.

One of the finest of the Pleistocene mammals was the great aurochs or wild ox (*Bos taurus*), the ancestor of our domestic breeds of cattle, and which was living in the Black Forest in the time of Cæsar. Even then it was described as but little inferior in bulk to an elephant, and those who have seen the gigantic skulls from the Ilford brick-earths preserved in the Natural History Museum, and have compared them with ordinary oxen, will have some idea of the magnificent proportions of the aurochs. Side by side with the latter lived bison (*Bos bison*) of equally gigantic size as compared with their living Lithuanian and Caucasian representatives (to whom the name of aurochs is persistently misapplied). Although the bison was very abundant in Britain during the cavern-period, it disappeared at an earlier date than its cousin the aurochs, its remains being unknown from the fens and turbaries, where those of the latter are so abundant. If we except certain remains assigned to sheep and goats, the only other hollow-horned ruminants that occur in the deposits under consideration are the musk-ox (*Ovibos moschatus*) and the saiga antelope (*Saiga tartarica*), both of which are of extreme importance as regards the nature of the climate then prevailing. Remains of both these animals have hitherto been obtained only from the south-east of England, those of the former occurring as far east as Maidenhead, as well as in the brick-earths of several places in Kent, and on the Dogger, while those of the latter are known only from Twickenham. It is thus very remarkable that these species occur exactly where the reindeer is unknown, and the suggestion naturally arises that conditions suitable for their existence may have occurred there and been wanting elsewhere. The musk-ox, which is now restricted to Arctic America, is such an essentially Arctic animal that it is hard to believe that it could have inhabited a country with a temperature suitable to the existence of the hippopotamus; while the saiga is equally characteristic of the open steppes of Russia.

Equally marked as the superiority of the fossil bison over its living representative was the excess in size of the Pleistocene red deer (*Cervus elaphus*) over its existing Scottish descendants, some of the antlers from the caverns and brick-earths being of enormous length and girth, and likewise notable for the number of points they carry. The fallow deer was certainly unknown from both the deposits last mentioned, although it has been said to occur in a bed on the Norfolk coast; but the superficial deposits of the same coast yield remains of the closely allied Brown's fallow deer (*C. browni*). In cavern-deposits the place of the fallow deer was more than filled by the splendid Irish deer (*C. giganteus*), generally known by the incorrect name of the Irish elk, and the splendid antlers of which are larger and more massive than those of any other member of the family. Although deriving its name from the abundance in which it occurs in Ireland, this deer is met with in most of the cavern-deposits, brick-earths and river-gravels of England; and it should be mentioned that although in Ireland its remains are commonly stated to come from the peat-bogs, they really occur in the shell-marl underlying the peat. In the outward direction of its widely palmated antlers, the Irish deer differs considerably from the fallow deer, but an extinct species recently described from the superficial deposits of Germany, under the name of Ruff's deer, so closely connects the two as to show that they constitute but a single group. The roe deer (*Capreolus caprea*), which is more a southern than a northern form, is found in many of the caverns, but is rare in the brick-earths; while the reindeer (*Rangifer tarandus*), although common in the caverns and superficial deposits both of England and Scotland, is, as already mentioned, quite unknown to the east of London. The wild boar, which is one of the most recently exterminated British mammals, requires a mere mention; but the hippopotamus of the British Pleistocene deposits, which, as stated in a previous article, is specifically inseparable from the common African species, is one of the most important of the whole fauna, so far as climatic conditions are concerned. Occurring commonly in the river-gravels and brick-earths of the south and midland districts of England, its remains are less frequent in caverns, although found as far north as Yorkshire. In our opinion, more importance is attached to the occurrence of the remains of this animal in a deposit than those of any other mammal, since we cannot conceive it possible that the creature could have existed except where the rivers were more or less open throughout the year.

Elephants were represented by the mammoth (*Elephas primigenius*), which may be considered merely as a northern hairy representative of the existing Indian species; and the so-called straight-tusked elephant (*E. antiquus*), which approximated in the structure of its teeth more or less markedly to the African elephant. Bounded to the south-west by the Pyrenees, and found but sparingly to the south of the Alps, the mammoth ranged northwards to Siberia, where, as already said, its frozen carcases are from time to time discovered, and where it must have existed in vast herds. It has recently been attempted to show that the mammoth lived and died before the glacial epoch; but although its remains undoubtedly occur on the old land-surfaces upon which the post-glacial deposits were laid down, the opinion of many geologists is hostile to the new view, and it is probable that the mammoth saw both the incoming and the waning of glacial conditions.

The rodents, or gnawing animals, need not detain us long, more especially since the burrowing habits of some of them render the occurrence of their remains by no means trustworthy evidence that they are contemporaneous with the other contents of the deposits where they are found. The beaver, although very rare in caves, occurs in the brick-earths of the Thames valley; while the Siberian and south Russian pica (*Lagomys pusillus*) has been found in three caves and the Ightham fissure. The northern vole (*Microtus ratticeps*) and the Siberian vole (*M. gregalis*), both of which have been identified from the last-named deposit, are animals essentially characteristic of desert or steppe regions; and much the same is true of the susliks (*Spermophilus*), several species of which inhabited England during the cavern-period.

It will thus be seen that the problems presented by the later Pleistocene mammalian fauna of Britain are so complex, and apparently so contradictory, that at present it is quite hopeless to arrive at any satisfactory conclusion. That so far as the larger mammals are concerned, we live in an impoverished age, is perfectly true; but whether, as Mr. Wallace supposes, this is due to the effects of the glacial period seems more than doubtful, if geologists are right (and we believe they are) in assigning a post-glacial date to our brick-earths, river-gravels, and cavern-deposits.

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THE PTOMAINES FORMED DURING PUTREFACTION.

By C. A. Mitchell, B.A.Oxon.

SELDOM does a year pass without the medical journals recording several cases of poisoning whose cause can only be traced to the eating of unwholesome meat or fish. It is no uncommon thing to hear of whole families suffering from the effects of eating mussels, while tinned meats and sausages are also sometimes found to be most dangerously poisonous. Sometimes the attack ends in death, as in the case mentioned by Czraut in his "History of Greenland," where thirty-two persons died from eating the brains of a walrus which had begun to decompose. In other instances only temporary indisposition is the result, even when a large quantity of the substance has been eaten. These symptoms, whose origin was formerly quite obscure, are now believed to be due to the presence of one or more of the *ptomaines* or animal alkaloids.

The name "alkaloids" was formerly confined to the complex nitrogenous bodies formed under normal circumstances by the vegetable protoplasm of certain plants, and containing, in addition to nitrogen, varying quantities of carbon and hydrogen, and in some cases oxygen. They may be solid and crystalline like strychnine, or a volatile liquid like nicotine, the alkaloid contained in the tobacco plant. They are more or less soluble in water, combine readily with acids to form salts, and have characteristic test reactions by which they can be distinguished from other bodies containing the same elements arranged in a different manner. Many of them act as deadly poisons on the animal system.

A similar class of substances is formed in living animals by the chemical processes of the body; these have been called *leucomaines*, while the alkaloids formed after death in the course of putrefaction have received the name of *ptomaines*. The leucomaines, of which the first known were extracted from normal tissue by Gautier in 1886, are in many cases non-poisonous, though some which have been prepared from the saliva and urine have proved fatal when injected in small quantities into animals. In composition they are, as a general rule, less complex than the ptomaines, though this distinction cannot be rigidly maintained. Brieger and others* do not allow their separate existence, and assert that they are not formed in the living body, but are ptomaines absorbed from the intestinal canal. The general consensus of opinion, however, seems to be against this view.†

That poisonous principles could be extracted from decaying meat was known long ago, but our knowledge of them is quite recent. In 1856, Prof. Panum of Copenhagen extracted from the flesh of dogs a poisonous substance which he called "putrid venom," and afterwards *sepsin*. The name *ptomaines* (πτωμα—a corpse) was first used in 1875 by Selmi of Bologna, who applied it to a mixture of alkaloidal products which he had separated from the putrefying remains of dead bodies. It has since become the general term for these products. It used to be thought that these animal alkaloids were different in kind to those formed in the vegetable kingdom,‡ but recent research has proved that they closely resemble each other in their properties, and are in some cases of apparently identical chemical composition.§

Brieger, to whom we owe much of our knowledge of the subject, defines the ptomaines as "all nitrogenous bases formed by the action of bacteria," but it is more usual to confine the term to those products formed during putrefaction. This process, as was shown by Pasteur in 1863, is a species of fermentation carried on by micro-organisms derived from the air. It is a property of vegetable and animal nitrogenous substances, and is the natural chemical sequel to life. After death, unless artificial means of preventing it occur, the work of splitting up complex substances into simpler and more stable forms commences. As Huxley says: "Tendency to equilibrium of force and permanency of form are the characters of that portion of the universe which does not live." Liebig's theory, that blood would not undergo putrefaction if protected from air germs, has since been again and again verified by only allowing access to air which had been sterilized by heating or filtration. Heating on successive days in steam or by dry heat at a higher temperature will destroy bacteria, or they may be removed by drawing air through cotton-wool, which will retain them; and Tyndall's experiments also proved that organic matter protected from micro-organisms would not putrefy. In this work of disintegration two classes of organisms bear part—the *aërobic*, which require the presence of oxygen, and the *anaërobic*, to which that gas is fatal. After death the body becomes a suitable culture medium for the reception of the anaërobic bacteria (*vibriones*) with which the air swarms. Some of these, falling on the body, draw their nourishment from the albuminous substance, splitting it up into simpler forms, and thus produce putrefaction. To complete the work of destruction the assistance of aërobic organisms is essential, for the *vibriones*, living without oxygen, sooner or later perish, and are themselves oxidized. Oxidation is the name given to the chemical process in which substances combine with oxygen. Since about one-fifth of the atmosphere is composed of this gas the process is continually going on in nature. Familiar examples of it are the rusting of iron and the burning of wood, where the heat enables the carbon and hydrogen in the wood to enter into combination with the atmospheric oxygen. The aërobic organisms which complete the work belong to the class of moulds, and on their advent the oxidizing process continues until the whole substance is transformed into the final simple and stable forms.

The mechanical process of putrefaction was studied by Gautier and Etard in 1882.‖ Muscles of beef and horseflesh, which were odourless and having a slight acid reaction, were exposed to the action of putrefactive organisms. After a time there was an acid odour, and a clear serum-like fluid exuded. This apparently coincided with the commencement of fermentation. Large bacilli were present, and the gases given off were ammonia and carbonic acid, with a little sulphuretted hydrogen, and phosphuretted hydrogen. Towards the fourteenth or fifteenth day free nitrogen began to be given off, and at this point putrefaction proper commenced. The large bacteria disappeared, being replaced by very small ones, which attacked the albuminoid substance, liberating carbonic acid gas and ammonia, and quickly causing the mass to become alkaline.

The germs producing putrefaction are in themselves harmless, and the poisons produced during their work are formed either by alterations in the substances on which they feed or by their secreting some chemical product. Prof. Burdon Sanderson has shown that when dead matter, such as blood serum, is deprived of every trace

* *E.g.*, Bouchard and Schär.

† *Cf.* Sir William Aitken's *Animal Alkaloids*; Gould's *Medical Dictionary*, 1890; Pouchet in *Dict. Encycl. des Sciences Medicales.*

‡ P. Spica, *Gazetta*, ii. 486-487. § Aitken, *Animal Alkaloids.*

‖ *Comptes rendus*, 1882.

of living organism, it still possesses the power of producing disease when introduced into the blood of animals.

Brieger* used the following method for extracting the ptomaines from human bodies: parts of the internal organs were placed in a cold cellar for from twenty-four to forty-eight hours. The mass was then made slightly acid with hydrochloric acid, heated nearly to boiling, and concentrated by evaporation. Alcohol was added to extract the alkaloid, which was then precipitated by platinic chloride. Alkaloidal bodies are readily dissolved by alcohol, and by filtration after treatment. With this the ptomaine would to a great extent be separated from other animal products. On now adding to the clear filtered liquid a solution of platinum chloride, which combines with alkaloids, a compound containing the ptomaine, insoluble in the alcohol, would be formed. This, filtered off, would leave most of the impurities still dissolved in the alcohol. From this combination the ptomaine *choline* was easily separated. If the putrefaction was allowed to proceed further other ptomaines besides choline were formed.

Like the vegetable alkaloids, some of the ptomaines contain no oxygen, while others have four or six atoms in the molecule. The term "atom" is a theoretical term to denote the smallest particle of a substance—that which cannot be divided any more. A "molecule" may be defined as the smallest particle of a substance capable of separate existence. There are usually two or more atoms in a molecule.

Mytilotoxine, the alkaloid separated by Brieger from putrefying mussels, may be taken as a typical ptomaine. Its percentage composition is—

Carbon	58·5
Hydrogen	4·0
Nitrogen	11·5
Oxygen	26·0
	100·0

Other well-defined animal alkaloids are *neurine*, which, like *choline*, is found in putrid flesh, and *tyrotoxicon*, which occurs in milk, and was the alkaloid separated in a case of poisoning by ice-cream.†

Most of them are extremely poisonous, and very minute injections have proved fatal to birds and small animals. The general symptoms are increased activity of the secretive organs and slowness of the heart's action, often followed by convulsions, paralysis, and death. In some of the cases of poisoning by putrid fish, there has been dilatation of the pupil of the eye and double vision. The action of *neurine* is stated to be very similar to that of *curare*.‡

Closely allied to the ptomaines in composition are the products formed by the pathogenic bacteria; they are termed *albumoses*, and may be obtained from pure cultivations of disease organisms after removal of these organisms by filtration through porous porcelain. Disease organisms are cultivated outside the body by introducing a fragment of diseased tissue or blood containing the organisms into a tube in which is some medium, such as gelatine, on which the bacteria can grow. When such a "colony" is obtained, containing only one species of micro-organism, it is called a "pure cultivation." It is highly probable that these albumoses are the poisons by means of which the bacteria produce certain diseases, for inoculation with them has produced results in some instances analogous to those obtained by inoculating with the bacteria themselves. Many of them are named after the disease with which they appear to be connected. Thus we have *diphtheridine*, obtained by Löffler from the pure cultivation of the diphtheria bacillus, and *scarlatinine* and *puerperaline* connected with scarlet and puerperal fevers. Quite recently§ Dr. Griffiths stated that he had isolated an albumose which he believed to be connected with influenza. It was a white substance, crystallizing in needles, soluble in water, and having a slightly alkaline reaction. Injected it was extremely poisonous, producing much fever, followed by death in eight hours. Whether it really is a cause of influenza requires corroboration, and indeed the whole subject is one in which further investigation is needed.

* *Ber. Deut. Chem. Ges.*, 17, 2741-2742.
† *Pharm. Journ.*, 1887. ‡ Aitken, *Animal Alkaloids.*

A PROLONGED SUNSPOT MINIMUM.

By E. Walter Maunder, *Hon. Sec. R.A.S., Physical Superintendent Royal Observatory, Greenwich.*

THE progress of the sunspot cycle has been on the whole so regular since Schwabe first demonstrated its existence, that we might easily assume it to be a fundamental law of solar change. Maximum has succeeded maximum, and minimum minimum, at an interval in each case so closely approaching eleven years, that we might confidently expect the present great activity to begin to decline within the next year or so, and to reach a minimum about the end of the century, as a year or two ago we were looking for some such a development of spots as we are beholding now. Some of the theories adopted to account for the cycle, indeed, assume it to have on the whole an unfailing regularity. The secret of the great solar outbursts has, for example, been ascribed to the return of Jupiter to perihelion. If this theory be adopted, then, since that return is regular, punctual, and unfailing, so ought its effect to be, and it should be as impossible for the sun to intermit two or three of its cycles as for Jupiter to wander from his orbit.

The sequence of maximum and minimum has, in fact, been unfailing during the present century. Within the experience of living observers the appointed time has never come round without the appearance of spots, vast in area, violent in change, and many in number; and one might be forgiven for inferring that as it has been for so long, it must always be, and must always have been. And yet there is the strongest reason to believe that for something like half a century, if not indeed for the full term of "threescore years and ten" allotted as the span of human life, the ordinary solar cycle was once interrupted, and one long period of almost unbroken quiescence prevailed.

If we turn back to the earliest volumes of *Philosophical Transactions of the Royal Society*, we find the first notice of a sunspot occurs in No. 74, dated August 14th, 1671, where it is stated that "at Paris the Excellent Signior *Cassini* hath lately detected again *Spots* in the Sun, of which none have been seen these many years that we know of." So novel, indeed, was the observation felt to be, that Oldenburg, the Secretary of the Royal Society, and editor of the *Transactions*, evidently considered it due to those interested in science to give an account of the last observations of the kind that had been secured in England. These had been made "by our Noble Philosopher, Mr. *Boyl*," in the months of April and May, 1660; that is to say, more than eleven years before.

Cassini's observations reached London in due course and appear in the next number of the *Transactions*, which

§ *Chemical News*, Nov. 17th, 1893.

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bears the date September 18th, 1671. His first words, which have been "English't out of the French," run as follows, and also point to the great rarity of sunspots at that period:—

"It is now about twenty years since that Astronomers have not seen any considerable *Spots* in the Sun, though before that time, since the Invention of Telescopes, they have from time to time observed them. The Sun appeared all that while with an entire brightness, and Signor *Cassini* saw him so the *ninth* of this month of *August*.

"But the *Eleventh* of the same, about six o'clock at night, being furnisht only with a three foot glass, he remarked in the Sun's disque *Two Spots* very dark, distant from his apparent Center about the third part of his Semi-diameter."

Then follows a description of the appearances of the spots and of their positions on the three days of observation, August 11th, 12th and 13th, but this, though so interesting to the astronomers of the time, need not claim our attention. The point of wonder to them was that any spots at all should be seen; the point of wonder to us is that they were not common and familiar objects.

This group was observed at its return in the next rotation, amongst others by Dr. Hooke, the celebrated Professor of Geometry at Gresham College. But after it had passed off the disc the second time the sun appears to have remained spot-free until November in the following year, when Le Monnier records the passage of a group. Then again a blank interval follows until in July and August, 1676, a fresh outburst occurred which drew the attention of several astronomers, our own Flamsteed and Halley in England, as well as Cassini at Paris. Later in the same year Cassini records another group which was seen during four rotations, and of this he says: "This is the third spot which has appeared in this year 1676, in which they have been more frequent than they have been during the twenty years preceding." A group is recorded in April, 1677, two or three in 1678. In connection with one of these appearing towards the end of May, Cassini remarks that the spot "was quite close to the limb in the middle of a region brighter than the rest of the surface of the sun, and was followed by a great number of other little markings of a like character. . . . These have been called Faculæ by Scheiner, who has often observed them. They have already appeared once this year, after the dissipation of the spots which appeared from the 25th of February to the 4th of March."

In 1680, spots were seen in May, June, and August, the group of May being a large one. In 1681, Siverus and Vagetius record spots in May and June. Then we come to 1684, when Flamsteed again has given us an observation of a spot on the sun's disc. "These appearances," he adds, "however frequent in the days of *Scheiner* and *Galileo*, have been so rare of late that this is the only one I have seen in his face since *December*, 1676."

This year, 1684, seems to have shown several spot-groups; 1686, two or three; 1687, none; for Cassini states in 1688 that "no matter what care he had taken to observe the sun when the sky was clear, he had not been able, since the year 1686, to detect any spot upon it until the 12th of May last." A few spots were seen in 1688 and 1689; then nearly six years passed without any being observed, for the next record is one of a great spot in May, 1695. Again a barren period set in, and it is not until the eighteenth century was about to dawn that we find any further observations. De la Hire and Cassini observed a great spot in November, 1700; the spot of May, 1695, was thus the only one recorded in a period of eleven years.

This long-continued dearth was now approaching its close. The Rev. William Derham, who made a special study of the sun at Upminster, has given a record of his observations in No. 330 of the *Philosophical Transactions*, and in most months of 1704 and 1705 one or more spots were seen. More remarkable still, in January, 1704, and again in October, 1705, the appearance of two separate groups on the sun at the same time was signalized. "Since the observations of Scheiner," is the comment of the *Histoire de l'Academie*, "made sixty years ago, one has scarcely ever seen two groups of spots on the sun at the same time." The wonder was, however, destined to become more common, for in 1707 it happened twice.

A new decline then set in. Derham's observation of a spot in January, 1710, and De la Hire's of another in October of the same year, appear to be the last for a considerable time, the sun being spot-free, according to Wurzelbauer, from the time of the disappearance of the last-mentioned group, October 29th, 1710, till May 19th, 1713. But a few years later quite a different state of things prevailed, and in 1716 the *Histoire* records: "This year has had still more spots than the preceding, and perhaps no other year has had so many. There have been twenty-one different appearances of them, counting only as a single appearance that of several different spots at a time. Only the months of February, March, October, and December have been free from them. In the other months the appearances closely followed each other, and to compensate several lasted only a short time. The phenomenon of two different spots at the same time has entirely ceased to be rare. It has been seen on April 20th and 21st, May 11th, July 26th, but that which is yet more remarkable, from August 30th to September 3rd eight different and totally distinct groups of spots have been seen in different regions of the sun. No diminution in the brightness of the sun has, however, been perceived."

With this great increase in activity, which rose to a yet more decided maximum in 1718, the long period of depression came to an end. It is not so certain when it commenced. A maximum was due, according to the ordinary course of the eleven years period, in 1649, but there are very few observations of spots at the time, and not a few notices in the years from 1648 to 1660 that the sun was spot-free.

Perhaps the most striking evidence we have of the reality of this prolonged dearth lies in the evident excitement and interest which the occasional appearance of a spot called forth. Picard, who independently discovered Cassini's spot of 1671, when at sea near the Texel, declares that he "was so much the better pleased at discovering it, since it was ten whole years since he had seen one, no matter how great the care which he had taken from time to time to watch for them." Cassini, again and again, and Flamsteed also, announce the time when a spot may be expected to return, for the benefit of their brother astronomers, since it is a "phenomenon which it is not in our power to see whenever we wish." And the references to the more prolific times of Scheiner and Galileo are not infrequent.

On the whole, then, it appears probable that after the maximum of 1639–40 had fairly died out—that is, after about 1643—a prolonged period of almost entire absence of spots set in, a period broken only by the very rare apparition of a single spot now and then, and by the feeble revival of 1703–7, and which cannot be considered to have terminated until the setting in of the maximum of 1715–20. For all this period, or at any rate from 1655 to 1703, the ordinary progress of the solar cycle appears to have been in abeyance, and we can hardly speak of it but as an extraordinary and immensely prolonged minimum.

And yet, just as in a deeply inundated country the loftiest objects will still raise their heads above the flood, and a spire here, a hill, a tower, a tree there, enable one to trace out the configuration of the submerged champaign, so the few solitary spots observed seem to mark out the crests of a sunken spot-curve. 1660, 1671, 1684, 1695, 1705, the years most notable for such stray spots as were observed, correspond as nearly as we can expect to the theoretical dates of maximum.

It may be objected, perhaps, that bearing in mind the feeble instruments of those days, and the paucity of observers, it may well have happened that many spots may have passed unnoticed during the seventy years in question. But no great instrumental power is needed to detect the presence of a sunspot, and indeed a single diligent observer using his unassisted sight during the last twenty-five years would have compiled a far heavier record than all the astronomers of Europe have been able to hand down to us for the years between 1643 and 1715. Besides, telescopes were certainly considerably more powerful than those in use earlier in the century. Yet we have but to refer to the works of Galileo, or to the plates, drawn with such evident care and fidelity, which adorn Scheiner's huge "Rosa Ursina," to be assured that outbursts such as the sun presented in 1625-27 could never have passed unnoticed fifty years later.

Nor were the observers few. In England there were Flamsteed, Halley, Hooke, Gray, Derham; in Holland, Huyghens; in Germany, Vogelius, Siverus, Vagetius, Wurzelbauer; in France, Picard, De la Hire, Maraldi, and above all Cassini. Indeed Derham, writing in 1711, well anticipates this objection. "There are," he says, "doubtless great intervals sometimes when the sun is free, as between the years 1660 and 1671, 1676, and 1684. In which time Spots could hardly escape the sight of so many curious Observers of the Sun, as were then perpetually peeping upon him with their Telescopes in *England*, *France*, *Germany*, *Italy*, and all the World over; whatever might be before, from Scheiner's time." And the fact that a new spot was apt to be independently discovered by more than one observer shows that the watch was carefully kept. The sentinels were neither few nor inefficient, nor can many stranger spots have eluded their vigilance, except under the cover of continued cloud.

A few, perhaps, did pass unnoticed. The watchful Cassini thus missed the spot of January 22nd, 1710, which Derham detected. Flamsteed let slip several which Cassini observed, but after making the utmost allowance for imperfection in the record there can be no doubt that the seventy years in question were barren of spots to a degree to which there has been nothing to correspond since.

The unanimity with which, when the earlier days of revival had come, all observers speak of the greater frequency of spots as quite a new experience, is irrefragable evidence that the change was a very real one. The *Histoire de l'Academie*, calling attention to this very change, states: "Since 1695, for example, up to 1700, none were seen. Since 1700, our histories have been full of them up to 1710, when only one was seen, and it would appear that they were drawing to an end." Derham, in 1711, refers to 1690-99 as a time "when Spots on the Sun were more rare than for these three or four years past they have been," and yet his record for these more prolific years, when compared with those of the present century, shows that 1704 and 1705, though so abnormally active as compared with the sixty years that had preceded them, were little (if any) richer than the years of an ordinary minimum. We expect now about sixty per cent. of the days of such a year to be free from spots; for the years immediately preceding or following minimum say about twenty-five per cent. Near maximum we expect to get five or six years running without a single instance of the sun being spot-free. And so far from two groups at once on the sun being a rarity, we look to have a dozen on the average, a number which may rise to seventeen or eighteen on occasion, as it did in December last; whilst a maximum year, like those of 1892 or 1893, will show three or four hundred distinct spot-groups, instead of the twenty-one which were considered so extraordinary a record in 1716. It would be quite impossible in these days for a Wurzelbauer, however small his instrument, to observe "daily" for five years without seeing a spot, or for a Cassini or Picard to do the same "from time to time" over a period of ten years, with a like barren result.

This long-continued solar rest suggests many questions to which we can find no reply. How we regret the absence of magnetic records, and how valuable would be a few of those ponderous volumes of rainfall and temperature that, when published by modern observatories and in these days, we are apt to look upon with scorn. The connection between the magnetic and sunspot curves is unmistakable to-day. Did terrestrial magnetism sympathize then with the long solar calm? Theorists have traced all kinds of connections between the solar changes and our cyclones, storms, droughts, and floods. Were those years marked off by any special meteorological peculiarity? For if there be any connection between the sunspot period and weather, so marked and so long-continued a minimum must surely have produced a most notable effect.

Again, faculæ and prominences vary in their number and size in close though not precise accord with the spots. How were those years distinguished for these phenomena? Cassini's allusion to faculæ, quoted above, is very significant, and points to as decided a dearth of the bright as of the dark markings of the solar surface. Unfortunately, there were no spectroscopes then, and we ask in vain for prominence observations. But there were a few total eclipses—those of 1654, 1659, and 1661—and they give us no hint either of red flames or of corona, whereas we get observations of both from the eclipse of 1715, and of the red flames from that of 1706. We cannot, therefore, say what shape the corona, which now appears to vary in such sympathy with the spot-curve, had during the period. Is it possible that, like the spots, it was in a state of partial abeyance?

Rightly and worthily was Schwabe honoured for his demonstration of the solar cycle, and for the great advance in our knowledge of the sun which that rendered possible. But the demonstration due to Wolf and to Spoerer of this strange interruption of it, is equally necessary to be borne in mind.* The sunspot theory which ignores it stands self-condemned. The very fact that the case is so anomalous renders it of more importance, and it may well

* In addition to the prolonged minimum referred to by Mr. Maunder, the theorist should bear in mind the irregularities in the length of the sunspot periods shown in Prof. Rudolf Wolf's sunspot curve, published in Vol. XLIII. of the *Memoirs of the Royal Astronomical Society*. Prof. Wolf's diagram represents many years of patient historical research, and shows in a graphic form his conclusions with respect to sunspot activity from 1745 to 1875. According to Prof. Wolf, the periods of sunspot maxima and sunspot minima do not ever occur with precise regularity. The variations from the mean seem to have been especially wide at the latter part of the last century; thus, according to Prof. Wolf, there was an interval of fifteen years between the sunspot maximum of 1789 and that of 1804, and only nine years between the sunspot maxima of 1769 and 1778.—A. C. RANYARD.

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prove of the greatest value to us in guiding us to a right understanding of the solar ebb and flow. In the meantime it stands as a warning to us against too hasty a generalization. Two centuries of a fairly cyclical oscillation would not have justified us in premising a like condition of things in the half century that preceded them. Clearly, however likely we may consider it that the present cycle will run much the same course as its immediate predecessors, we are not justified in prophesying it. What has happened before may happen again, or even its reverse; for who shall say it is impossible that, as for so long a time the keynote of solar energy was lowered to such a degree, so for an equal time it may not be proportionately raised? If so, we or our descendants may see our sun as an unmistakable variable star; for the vague traditions which have reached us from the middle ages may be realized, and for a greater or less time the sun may be so covered with spots as to lose a very appreciable portion of the light of its general surface.

In this case we should probably find the faculæ and prominences developed in something like the same proportion, and the sun might well earn the title of a "bright line star" in a sense which we have never known it to do as yet. And its spectrum would approximate to those of the transitory enigmas which have puzzled us so sorely—the "temporary" stars of Auriga, of Norma, and of the Northern Crown.

INSECT SECRETIONS.—IV.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 149.)

THE fresh and luxuriant herbage, consisting of grasses and other low plants, which forms so lovely an undergrowth in woodlands and waysides in early summer, is generally seen to be more or less disfigured by the presence of numerous patches of white froth or spume scattered about over the stems and leaves. Popularly classed amongst that vague and indefinite group of objects known to be injurious to vegetation, to which the name of "blight" is loosely applied, these masses of froth are specifically distinguished as "cuckoo-spit," "frog-spittle," or "spittle-blight," and so abundant and widely distributed is this substance, that it forms one of the commonest of the "common objects of the country," and there can be no one who has not been familiar with it from his earliest years. The legendary association of this froth with the cuckoo is to the effect that the bird, becoming hoarse by the constant reiteration of the same cry, is at last driven to relieve its throat in the offensive way to which the surrounding bushes bear testimony. The association with frogs, though equally wide of the mark, has a little more show of plausibility; for the froth is the produce of several of those curious insects mentioned in our last paper, which, from their strange, angular heads, and their long hind legs and great leaping powers, bear a ludicrous resemblance to minute frogs, and are commonly known as frog-hoppers. If the mass be examined, there will be found imbedded within it a soft-bodied, greenish or yellowish creature, which is either the larva or pupa (Fig. 10) of some member of the family *Cercopidæ*. In the majority of cases, it would prove to be the young of one of the most abundant of all British insects, *the* frog-hopper *par excellence*, which is named scientifically *Philænus spumarius*.

In this insect we again have an illustration of the order Homoptera, which furnished us with all the examples dealt with in our last paper, and like the rest of its tribe, it feeds upon the juices of plants, which it abstracts by aid of a beak-like apparatus bent under the head. The beak consists of the trough-like labium which contains pointed needles, the representatives of the jaws of the typical insect's mouth. Around the hinder part of the digestive tube, which is unusually long, lies a coiled gland which, according to Buckton, secretes a slimy liquid; this liquid issues from the end of the body, and at the same time air is forced into it, thus throwing it up into bubbles which pass out one by one and roll round till they form a mass of froth completely enveloping the insect. It is not very easy to see how the air gains access to the liquid secretion, since the latter issues from the end of the digestive tract, which is in communication with the air at no other point than the mouth, where no air is taken in. Any air that is drawn into the body of course enters as usual at the sides through the spiracles, and passes thence into the various air-tubes of the body. That the air in the bubbles does actually come from within the body, and is not drawn from the outer air at the place of their formation, seems to follow from the fact that if the insect be plunged into water, it continues for a time to emit air-bubbles from the end of its body.

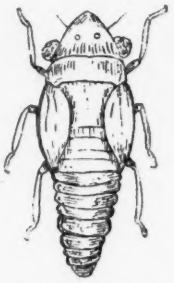

Fig. 10.—Nymph of Cuckoo-spit Insect, with froth removed. Magnified seven diameters.

In order to watch the process of formation of the froth, the best plan is to adopt the method originally employed by the celebrated naturalist De Geer. He took one of the larvæ, and with a little brush carefully removed all the froth surrounding it; then he placed it on a freshly-cut twig of honeysuckle, a plant much frequented by these insects. The twig was placed with its cut end in water, that the loss of moisture by evaporation might be counterbalanced, and the plant might continue to be sufficiently succulent to yield the insect an abundant supply of sap. It soon drove its beak into the stem and began to suck, continuing the operation for some time; then withdrawing its beak it walked off to a leaf, and there began to bend the hinder part of its body about in different directions. De Geer, who was all the time watching it with a lens, soon saw a little bubble issue from the end of the digestive tract and roll round under the body. A repetition of the same movements soon produced another bubble, which followed its predecessor, and the operation was thus continued till the whole insect was covered with a pile of white bubbles, the viscidity of the liquid of which they were composed being sufficient to prevent them from bursting. Sometimes two or three specimens form their froth side by side, so that they become enveloped in a common mass.

This frothy covering serves in general a twofold purpose. In the first place the enclosed insect is protected from insectivorous foes, most of which would think twice before interfering with a sticky, slimy mass of froth, however tempting the morsel within might be. But still the immunity is not absolute; some predaceous insects are bold enough to brave the discomforts and dangers of the sticky mass and carry off its inmate. De Geer records that he saw some "small wasps" do this; these were probably not true wasps, but yellow-banded Hymenoptera, belonging to the genus *Gorytes*, some species of which have also been found by other observers, carrying off the larvæ to their nests. This would, however, be to serve as food for their young rather than to feast upon themselves.

The second use of the froth is that it shields the enclosed insect from the heat of the sun, which, instead of drying up its delicate frame, simply promotes evaporation in the fluid mass. The loss from such evaporation is usually counterbalanced by renewed secretion, although, in very dry weather, when the vegetation is less succulent, the mass shrinks considerably in bulk, and at last reaches a degree of concentration in which evaporation seems to be almost entirely checked. In damp weather, on the other hand, the secretion is very abundant, and a clear drop of liquid devoid of bubbles often hangs at the end of the mass, ready to fall on the slightest agitation of the leaves. The soft-bodied larvæ of the tribe of frog-hoppers usually feed from the under-side of leaves, thus placing the broad shelter of the leaf-blade between themselves and the prying eyes of birds, or the searching rays of the sun. But the larvæ of the particular group we are now discussing, by the habit of froth-secretion, are able to feed exposed on the upper surface, and still more or less successfully defy the evil influences which are the bane of their less highly protected brethren.

The insect spends the whole of its larval and pupal life enveloped in this froth, and usually feeds with its head downwards; it even changes its skin while bathed in the moisture of its own distillation, and the rejected vestments may sometimes be found floating in the mass. The stickiness of the froth causes it to become a good trap for minute insects and other odds and ends that may be floating about in the air, and miscellaneous collections of such objects may sometimes be found in it. By the time the frog-hopper is ready to assume its perfect state, the froth has considerably evaporated, and then it forms a hollow envelope, not in close contact with the insect's body. Within this central cavity the final change takes place. When it has reached its ultimate form, it escapes from its hollow shelter, and thenceforth dispenses altogether with the secretion, spending the rest of its days as a dry, hard-bodied, vigorously-leaping creature, which, though common enough, and frequently seen, is so changed in appearance that it is not likely to be associated, in the minds of those ignorant of its history, with the frothy masses which disfigured the plants a few weeks earlier.

Philænus spumarius (Fig. 11) is one of the most variable insects of which our country can boast, and any attempt to describe its coloration briefly is almost futile, for it is not easy to find two specimens alike. Its angular head, its stout and spiny hind legs, and its horny upper wings, slightly rounded on the outer edge, will at once enable it to be recognized quite apart from coloration. It is sometimes brownish, more or less speckled and spotted with paler markings; or, again, it has black upper wings and a whitish head, or purplish-black upper wings with conspicuous white bands upon them. Sometimes it is entirely pale drab, or yellowish brown, with a pinkish tinge. And so one might go on describing variety after variety of the most opposite appearances, yet all agreeing in shape and structure, and evidently no more than mere varieties of the same insect. Upwards of a dozen of these varieties are sufficiently constant to have received distinctive names.

Fig. 11.—Perfect Insect of Cuckoo-spit (*Philænus spumarius*). Magnified four diameters.

Considering its extraordinary abundance, *Philænus spumarius* probably does far less damage than might have been anticipated, though of course the abstraction of sap from the young and growing parts of plants has always the effect of stunting their growth and producing malformations. But in gardens there is more reason to dislike it because of the disagreeable appearance of spittle-like masses clinging to the plants, and the ease with which they become transferred to one's fingers, than for the actual amount of damage done. The insect, though a very general feeder, is somewhat of an epicure in its tastes, and requires its food in a very fresh state. Hence it is not easy to keep in confinement except on growing plants, for if the sap at all deteriorates in quality, the creature crawls out of its froth and goes in search of more favourable quarters; not being able to find such, it resigns itself to death rather than touch food of an inferior quality. Its habit of living enveloped in moisture enables it to endure immersion in water for a considerable time. When first put in it emits bubbles, as already described, till its supply of air is exhausted, and then lies quiescent and apparently dead. But on being taken out, even after an hour's submergence, it recovers and seems none the worse for its experience.

We have already pointed out that the froth of the *Cercopidæ* is not wholly effective in preserving the larvæ from the attacks of other insects, and this is true also when those insects are parasites on the look out for a suitable place of deposit for their eggs. Small ichneumon flies manage to gain access to the larvæ of the different species of spittle-blight and lay their eggs in their bodies. In such cases, Mr. Buckton speaks of having found the shrivelled body of the host, after the maturation and exclusion of the parasite, enveloped in a kind of cage of hollow network, consisting of the dried up remains of the frothy cover. This was a larger species than that described above, and belonged to the genus *Aphrophora* (foam-bearer), a name originally assigned to all these insects because of their frothy secretion. The species in question is found chiefly on willows, and is not nearly so common as *Philænus spumarius*. We have altogether seven species of frog-hoppers in this country that manifest the habit of froth-forming, one of which, the scarlet-hopper, is an extremely handsome insect with black wings crossed with blood-red bands.

The honey-dew of aphides is another homopterous product of considerable interest. The majority of the aphides carry on the sixth segment of the body a pair of tubes pointing more or less upwards and outwards, and called "cornicles." Out of these tubes there may at times be seen to issue drops of a saccharine liquid (Fig. 12), which remain for a while adherent to the end of the tube and then drop off. This is what is known as honey-dew, so called from its being found sprinkled as sweet and sticky patches on the surface of leaves, as if the air had deposited honey in the same way as dew. Such, indeed, was the origin assigned to it in ancient times, as it appeared on the leaves of trees without any obvious cause, and Pliny in referring to it, shows that he was divided in his mind as to whether he should ascribe to it a celestial or a mundane origin—whether, in fact, he should regard it as the "sweat of the heavens, the saliva of the stars, or a liquid produced by the purgation of the air."

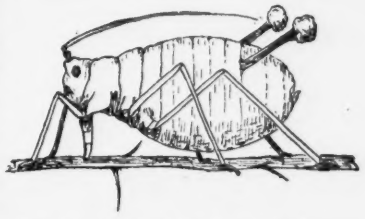

Fig. 12.—Aphis of the Rose, with honey-dew on cornicles. Highly magnified.

The cornicles of aphides do not appear to be directly connected with secreting glands, but simply to open into, or rather from, the cavity of the body. The saccharine

liquid is ejected not merely from these cornicles, but also from the extremity of the digestive tract, whence it is sometimes forcibly shot to some considerable distance. Buckton states, with reference to the black aphis which is found on willows, that if its abdomen be stimulated with a bristle, it will erect the terminal rings of its body, and upon the apex there will appear a clear drop of liquid. If ants happen to be near at the time, they will at once abstract this, but if not, the aphis projects the globule with a jerk to a considerable distance, and in consequence it falls on the leaves below.

The leaves of some trees are often seen to be thickly covered with spots of this sticky substance. The lime tree is specially noted in this connection, and when such a tree grows in a garden and overhangs the pavement, it is matter of common observation that the surface of the latter underneath the tree becomes, during the course of the summer, thickly bespattered with drops of the same honey, as though there had been a constant rain of it on to the ground. In such cases the question has arisen, and it is one that has provoked a good deal of controversy, whether the fluid is not a direct product of the tree itself rather than of the aphides, and such an idea seems to gain support from the fact that the trees that give the most plentiful showers on the ground and have their leaves in the most foul condition, are not always those that are most infested with aphides. There seems to be some probability that both statements are true. It is certain that aphides do produce such a liquid as this, and indeed its manufacture by them forms the reason why ants keep stores of aphides for their own profit. If the liquid does not exude from the bodies of the aphides naturally, when required by the ants, they will stimulate the creatures to yield it, by stroking their bodies with their antennæ. Under this gentle stimulus, drops of liquid soon issue from the cornicles and are eagerly received by the attendant ants. It seems likely that just as the milking of a cow by a human being is a relief to the animal through the relaxation given to the painfully distended udder, so the aphis may feel it a relief to discharge, under the stimulus of the ant's antennæ, the fluid with which its body is fully charged, and thus the operation may be an advantage to both parties to the compact. Harting collected some honey-dew from the aphides of the lime tree, which were caused to discharge it on a glass plate; it was analyzed and found to consist chiefly of cane sugar.

But the fact that aphides do secrete honey-dew, deriving it ultimately, of course, from the sap of trees, is no reason why a similar product may not also be elaborated by the plants themselves; and it is certainly difficult to believe that the great amount that is found on the leaves of limes, maples, &c., as well as on the ground beneath them, has its origin entirely with the insects. A similar liquid occurs, in the form of globules, in the pseudo-galls produced on poplar and other trees by the agency of aphides. Passerini says that in Italy this substance is collected from the leaves of elm trees, and used by the villagers, under the name of St. John's oil, for the dressing of wounds. In the same way the liquid found in the aphideous galls of elms is said to be used in France, under the name of elm-water, as a remedy for sore eyes.

Aphides are not the only insects that secrete a substance grateful to ants. Several other insects belonging to the order Homoptera, and especially to the section of frog-hoppers, are attended and caressed by ants, who evidently derive something agreeable from them. The following details, which have been communicated to me by a correspondent, refer to a kind of frog-hopper which is an inhabitant of Australia, in the neighbourhood of Sydney. "We first noticed the ants running about on the twigs of a bush in an apparently excited but inconsequent manner, and on looking closer we found they were swarming over a number of the frog-hoppers distributed over the branches as if they were aware of the presence of something which they failed exactly to localize. Watching isolated couples, we noticed every now and then a small drop of clear substance resembling honey exude from the frog-hopper rather more than three parts down its back, which the ant immediately slipped round and devoured. There did not seem to be a systematic milking as in the case of the plant-lice, but the ants, in trying to find the secretion, seemed to hit upon the trick accidentally. The insects did not make the slightest effort to get away; they all seemed in a drowsy condition, and in many instances crowds of ants were swarming over them." Some American ants have also been observed licking the caterpillars of a certain blue butterfly, over which they assume guardianship. The caterpillar secretes from an oval gland on its back a sweet liquid which is much sought after by the ants, who stimulate its flow with their antennæ and then eagerly lick it up. In some places they are even said to go so far as to treat the caterpillars in much the same way as certain British species do their aphides, by erecting a sort of earthen shed over them to protect them when they become pupæ.

It is probable that a good many caterpillars have the power of secreting liquids of one kind or other, which are no doubt useful for protective purposes. The caterpillar of the puss moth is remarkable in this way, as it has the power of discharging formic acid from a gland situated beneath the mouth, a portion of the gland itself being at the same time everted. Similarly the caterpillar of the beautiful swallow-tail butterfly, when alarmed, thrusts out a forked appendage behind its head and exhales a strong odour of fennel. The stinging glandular hairs of the processionary moths, as well as of our English gold-tails and brown-tails, are other instances of protective secretions. The caterpillar of the goat-moth, again, receives its popular name from the secretion, which gives it so strong a smell that its burrows in the solid wood of tree trunks become deeply impregnated, and its presence can be recognized at a distance by the powerful odour emanating from them. Some caterpillars when handled cause a disagreeable dark green or brown liquid to issue from their mouths, and thus no doubt often escape from their enemies.

The habit of secreting liquids is carried to an excess by the larvæ of certain saw-flies. They are pale, greenish, fleshy, caterpillar-like beings, covered with little warts (Fig. 13). They are found on hawthorn and other bushes, on the leaves of which they may be noticed lying with their tail coiled round towards the head, and making no attempt at concealment. Their bodies are generally rather stiff, and the skin seems fully distended; just above the spiracles are minute openings from which a clear acid liquid can be forcibly squirted to some distance, and when the creature is seized with the fingers, one is sure to receive a little battery of jets before it resigns itself to its fate. Another and much smaller species covers its body with a horrible slime, which gives it a slug-like appearance, whence its popular name of slug-worm. Not only do these slug-worms look repulsive, but they also exhale a sickening smell, which is particularly noticeable when a number are feeding together. They do great damage to fruit trees, eating away most of the soft part of the leaves.

Fig. 13.—Larva of Saw-fly.

(*To be continued.*)

ON THE DISTRIBUTION OF STARS IN THE MILKY WAY.

By W. H. Wesley, *Assistant Secretary of the Royal Astronomical Society.*

THE question whether the stars of the Milky Way are arranged in curves and streams, or are scattered without any tendency to aggregation into elongated groups, is one of such importance and so materially affects our ideas as to the nature of the galactic stream and of the visible sidereal universe, much of which is evidently connected with the Galaxy, that I need not apologize for critically examining the evidence as to the actual, or only apparent, existence of such star groups.

Many of the lines of stars to which Mr. Ranyard has called attention, in his series of papers on the structure of the Milky Way, are composed of stars of different magnitudes, and the long groups or lines of stars frequently do not curve with a regular sweep or curvature. If the stars which thus fall into line correspond to an actual star stream in space, and their alineation is not due to the optical juxtaposition of stars which are really widely separated, and which only appear to be close to one another as seen from the earth's position in space, the star stream must itself be irregularly curved, and I admit that such irregular curvature would appear to indicate that the various stars of the star stream have shifted their relative places since the formation of the stream, and that probably the easiest way of accounting for such a shift would be to assume that the stream has been projected into a resisting medium.

This, however, assumes the actual existence of the streams, and discards the theory that the human mind has a tendency to find such streams in every thickly clustered random group of points, a theory which is naturally adopted by those who remember that they can with very little effort of the imagination see faces in the fire and likenesses of eminent men in the outlines of mountains or on the side of a cliff, to say nothing of the wonderful likenesses to the human face which are to be found on the backs of insects and crustaceans, or on the face of the moon. The question is one which I think can hardly be settled by mere mathematical considerations of probability, for the curves of stars found in the Milky Way are not regular or simple curves. I willingly grant that if four points fall accurately on a circle, the arrangement is probably not accidental, but the considerations involved when the curve is an irregular one are so complicated that I prefer to try and solve the question experimentally, rather than to try and think it out theoretically.

Artificial Star field, made by sprinkling spots of Indian ink upon paper.

For this purpose I have many times repeated the experiment of sprinkling small splashes of Indian ink upon paper with a brush, taking care to revolve the paper between each sprinkling, so as to avoid the chance of showing any artificial grouping in lines due to the direction in which the spots of ink were thrown from the hairs of the brush. Mr. Ranyard has kindly had two of such artificial star fields reproduced by photography. In many instances it is difficult at first sight to distinguish the artificial fields from real photographs of star fields. The eye easily picks out many chains of dots in my artificially made star fields; but where the chains are long, the dots,

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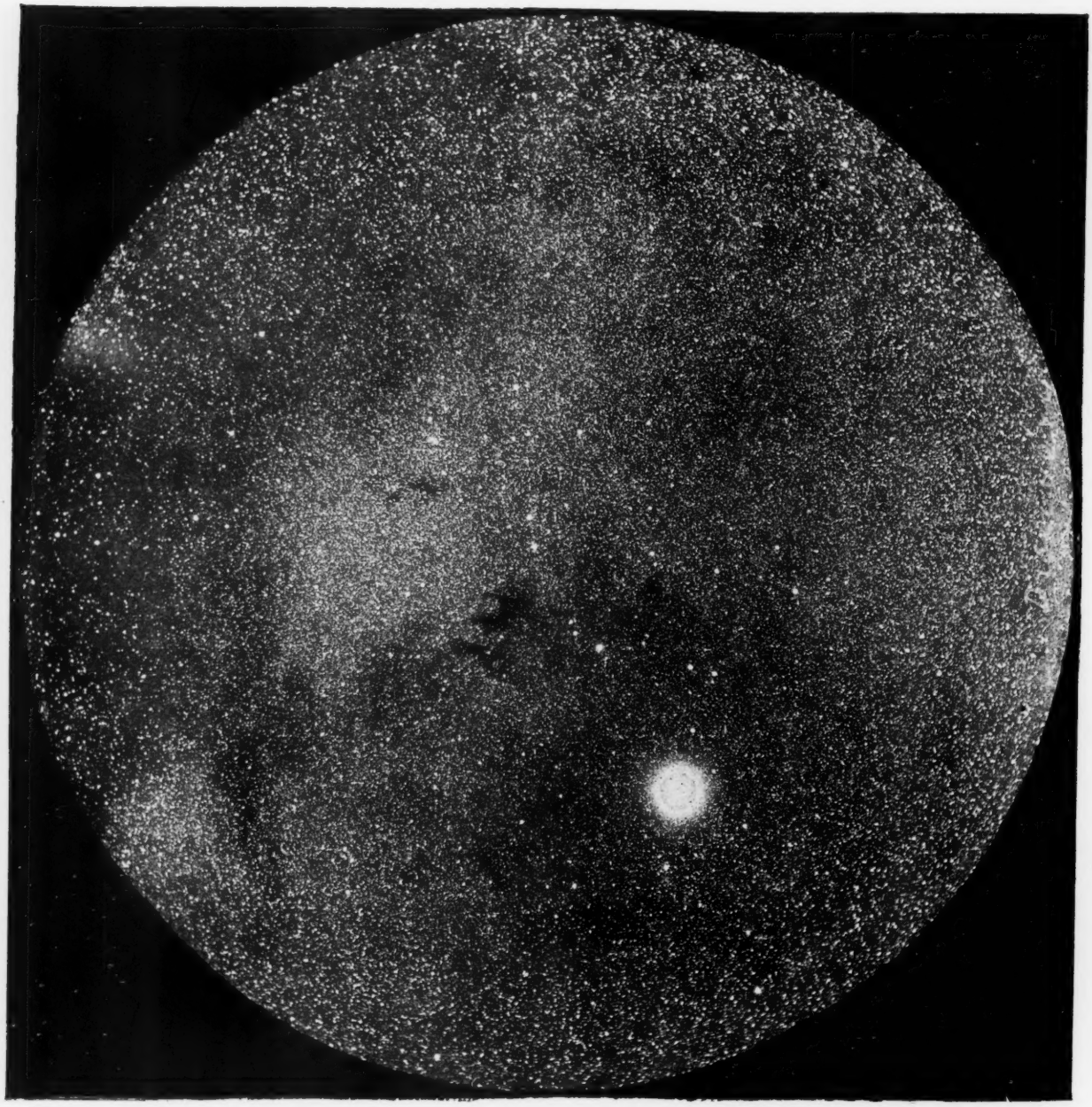


THE MILKY WAY IN THE CONSTELLATIONS AQUILA AND SAGITTA.

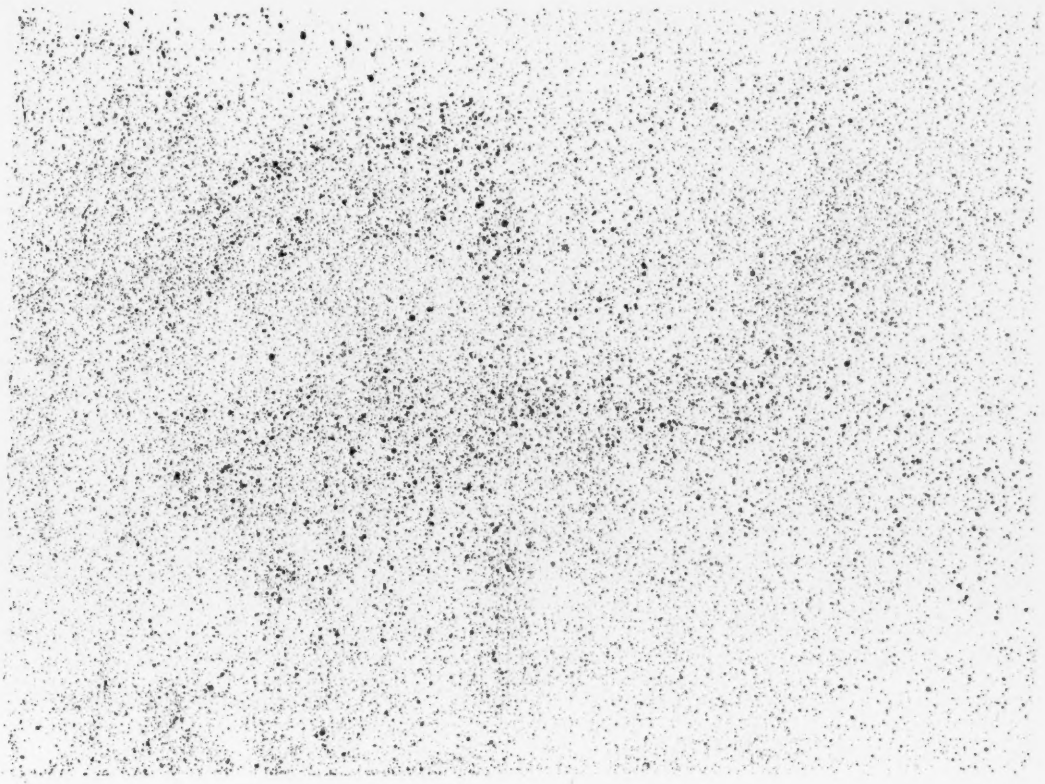
From a Photograph by Prof. E. E. Barnard, taken at the Lick Observatory, 12th October, 1892, with a six-inch photographic lens, and an exposure of 4h. 20m. Centre of plate, α = 20h. 30m., δ = + 12°.

perhaps, vary more in magnitude, and the intervals are not so regular as in some of the strings of stars shown upon star photographs. There is not quite such a range of magnitude of the patches representing stars in the stellar photographs as of the dots in the artificial star plates; for the smallest stars on the photographs are represented by spots of sensible magnitude, which are fainter, but not much smaller than the denser images of stars a magnitude or two brighter.

I do not wish to appear to urge that the chains of dots on these artificially made star fields should be taken as proving that all strings of stars in the Milky Way photographs must be deemed to be optical or mental illusions, for there are some lines of stars in the heavens—as, for example, those in the Pleiades group—which are joined by a nebulous band, and which evidently, therefore, have a physical connection with one another. There are also many regularly spaced strings of stars of similar magnitude, such, for example, as those diverging from the nebulous mass to the north of the trifid nebula (photographs of which are reproduced in the January number of KNOWLEDGE for 1893), about the actual existence of which streams nobody who has carefully examined the photographs could have any reasonable doubt. I would also make exception in the case of many of the radiating streams from star clusters, whose radial arrangement with respect to the centre of the cluster, and the way in which they branch in a direction away from the cluster, seem to indicate that they have sprung from the cluster, and represent streams of matter shot forth from it.

The strings of stars which the eye detects in the artificial star fields teach us that extreme caution must be exercised before we assume that any particular row of stars in the Milky Way forms a star stream that has probably condensed from a single stream of nebulous matter, and which, with greater illumination, would possibly be found to be linked together by a faint nebulous band, like the lines of stars in the Pleiades.

There is one marked distinction between the artificial star fields and the Milky Way photographs. In the photographs there are many dark areas with more or less sharply defined edges, but in the artificial star fields where vacuities occur the less crowded areas have no definite edges, and they show no tendency to assume branching forms; in fact, they do not in the least degree resemble the definite dark areas which are found in so many parts of the Milky Way. Some striking dark areas are shown on the Milky Way photograph which accompanies this paper. The photograph was taken by Prof. E. E. Barnard with a photographic lens six inches in diameter, known as the Willard lens, which is mounted on the six and a half inch equatorial of the Lick Observatory; it represents a portion of the Milky Way in Aquila and Sagitta. The photograph is reproduced in the plate on a scale about two-thirds that of Argelander's maps, and it covers a circular area about thirteen and a half degrees in diameter. The very bright star is α Aquilæ (Altair), which is of the 1·5 magnitude. It is much over-exposed, and appears larger and brighter in the photograph as compared with β and γ Aquilæ than as seen with the naked eye. γ Aquilæ, which is of the third magnitude, lies between α Aquilæ and the centre of the plate. At a distance of about half an inch from the circle which bounds the field, β Aquilæ, which is of the



Artificial Star field, made by sprinkling spots of Indian ink upon paper.

fourth magnitude, lies at nearly an equal distance on the other side of Altair. Near to the centre of the plate is a large patch of nebulosity, corresponding to a portion of the Milky Way which runs through the constellation Sagitta. This portion of the Milky Way is clearly indicated on the drawing of Dr. Boeddicker, who also shows something of the dark vacuities between this mass and γ Aquilæ.

The plate is interesting as being the first on which the trail of a comet was photographed. In *The Observatory* for February, 1893, there was given a reproduction of a small portion of this plate, very much enlarged, to show the comet's trail, but the enlargement was too rough to be intelligible. I therefore give a sketch here, showing the nebulous streak imprinted on the plate by the comet during the exposure of four hours twenty minutes. Prof. Barnard's photograph has, in the process of reproduction, been reversed right and left. Allowance must, therefore, be made for this in comparing the diagram with the photograph.

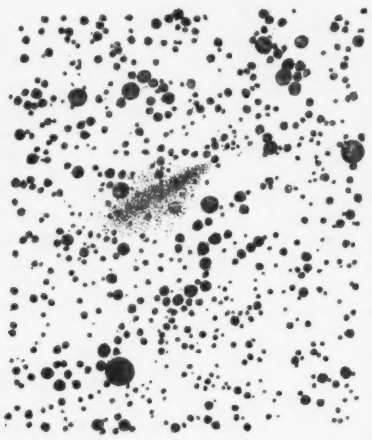


Diagram sketch of Trail of Comet.

I chiefly wish, however, to draw attention to the remarkable dark markings on the plate between the comet and Altair, of which I add a sketch as a diagram to direct the reader's attention. It will be seen that, except towards the left in the diagram (*i.e.*, to the right in the photograph), where they end gradually, the edges of these markings are perfectly sharp. They seem absolutely free from nebulosity, and only a few scattered stars appear upon them, while the regions immediately surrounding them are densely covered with stars which appear to have a faintly nebulous background, possibly resolvable into stars. On the transparency from which the plate has been made there can be counted, on the small enclosed space marked *a* in the diagram, about fifty bright stars, and nearly as many faint ones in the nebulous area of the same patch. In some places also the edges of the dark markings appear outlined with fairly bright stars, though this feature is not nearly so conspicuous as in the nebula round η Argûs, to which Mr. Ranyard has already drawn attention.

Diagram showing dark markings. Reversed right and left as compared with the plate of Prof. Barnard's photograph.

To me these dark markings are of the greatest interest, and I am quite unable to see any force in the arguments which have been used to minimize their importance. It has been urged, for instance, that their appearance on the plates is merely a matter of *exposure*; and that with an increased exposure they would be filled with stars and disappear. This certainly does not seem to be the case with some of them; for example, the dark marking known as the "kidney bean marking" of Sir John Herschel, in the η Argûs nebula, certainly increases in distinctness with increased exposure. But granting that prolonged exposure would fill these spaces with stars, nothing is proved, except that they are not vacuities extending through all space, and in directions exactly coinciding with the line of sight, which would be exceedingly improbable.

Again, it is urged that the dark markings may be simply interspaces between masses of nebulosity, like patches of sky showing between clouds. But the definite boundaries of the dark spaces, and still more the edgings of bright stars, seem entirely to negative this supposition.

That the dark spaces in the Milky Way are caused by dark or light-absorbing matter, lying between us and the general mass of the stars, appears a reasonable supposition, and in many cases it seems difficult to account for the appearance observed in any other manner.

The dark markings upon the photograph under consideration seem to be entirely between us and the mass of stars which occupy the central region of the plate, but in other cases the dark matter seems to be intimately associated with the stars surrounding them, otherwise it is difficult to account for the lines of bright stars that frequently appear at the edges of the dark markings.

On the whole, the most probable hypothesis which has yet been put forward appears to me to be that which Mr. Ranyard has urged, viz., that they may be due to streams of heated but not luminous matter, which condenses at its outer portions into stars or masses of luminous nebulosity. This would also explain the branching or tree-like forms which the dark streams so frequently assume, and which make it appear that the dark matter is projected into a resisting medium. In any case, I feel convinced that the markings in question are *real*, and are no mere casual interspaces.

[I am glad to publish Mr. Wesley's cautious discussion of the evidence with respect to the existence of streams of stars in space. The importance of the conclusions as to the evolution of the stellar universe which follow from the admission of such evidence is so great that we cannot be too careful in examining the foundations on which our conclusions are based. Mr. Wesley seems to be satisfied as to the actual existence of many of such star streams, especially where they radiate from star clusters. I would point out that the Milky Way is itself a great cluster of stars, and if such star streams are intimately associated with the smaller clusters, it seems not improbable that a vast cluster like the Milky Way also contains many such streams; but I am not concerned to show that all the Milky Way stars are arranged upon recognizable streams. The fact that streams of stars exist, and that they are frequently associated with streams of dark nebulous matter, ought materially to modify our conclusions with regard to the permanence of stellar systems.—A. C. Ranyard.]

CLOUDSCAPES PHOTOGRAPHED AT THE SYDNEY OBSERVATORY.

By H. C. Russell, F.R.S.

In forwarding the accompanying cloud photographs, Mr. Russell says:—"I am forwarding you a few of our cloud photographs, which, although they belong to well-known classes, are very different from those photographed in Europe. In one or two cases I have been surprised by obtaining a fairly good photograph of the landscape as well as a well-exposed photograph of the clouds. The cloud photographs are taken here as part

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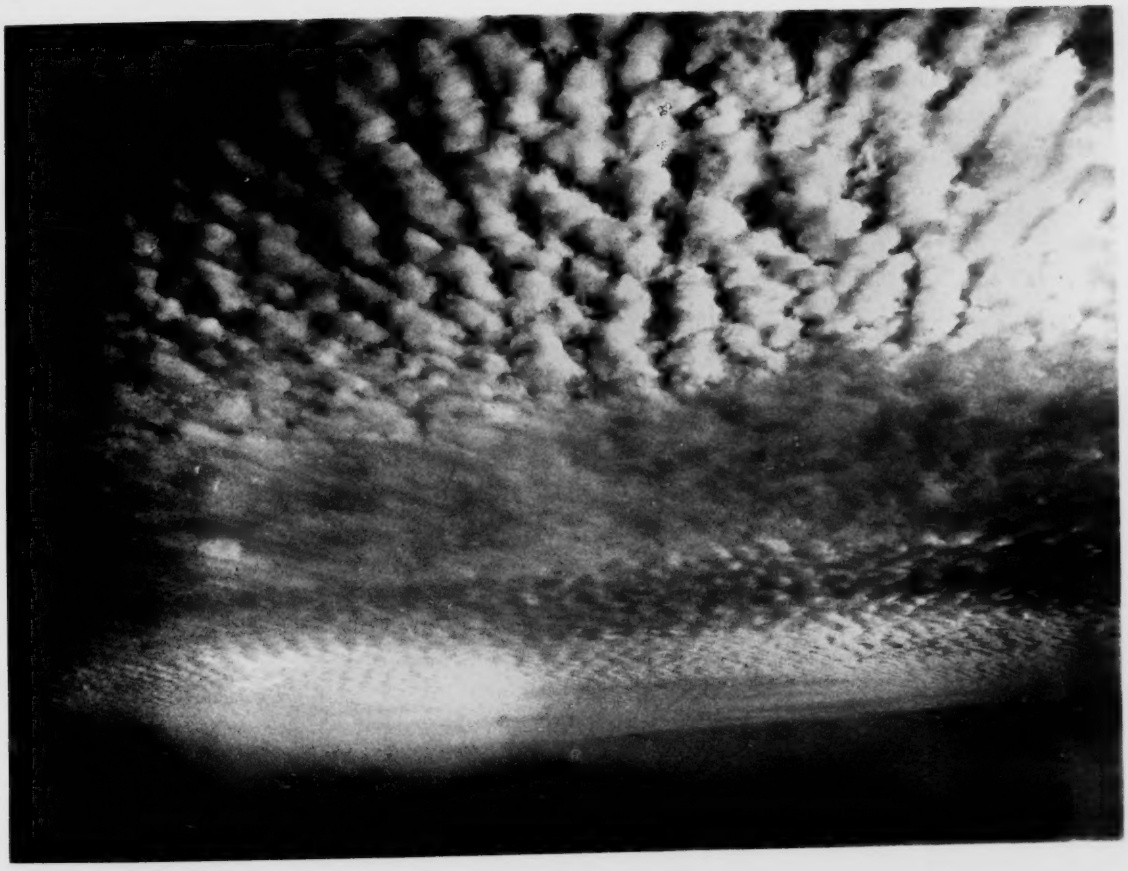

PHOTOGRAPHS OF CLOUDS. TAKEN AT THE SYDNEY OBSERVATORY, NEW SOUTH WALES.

By H. C. Russell, F.R.S.

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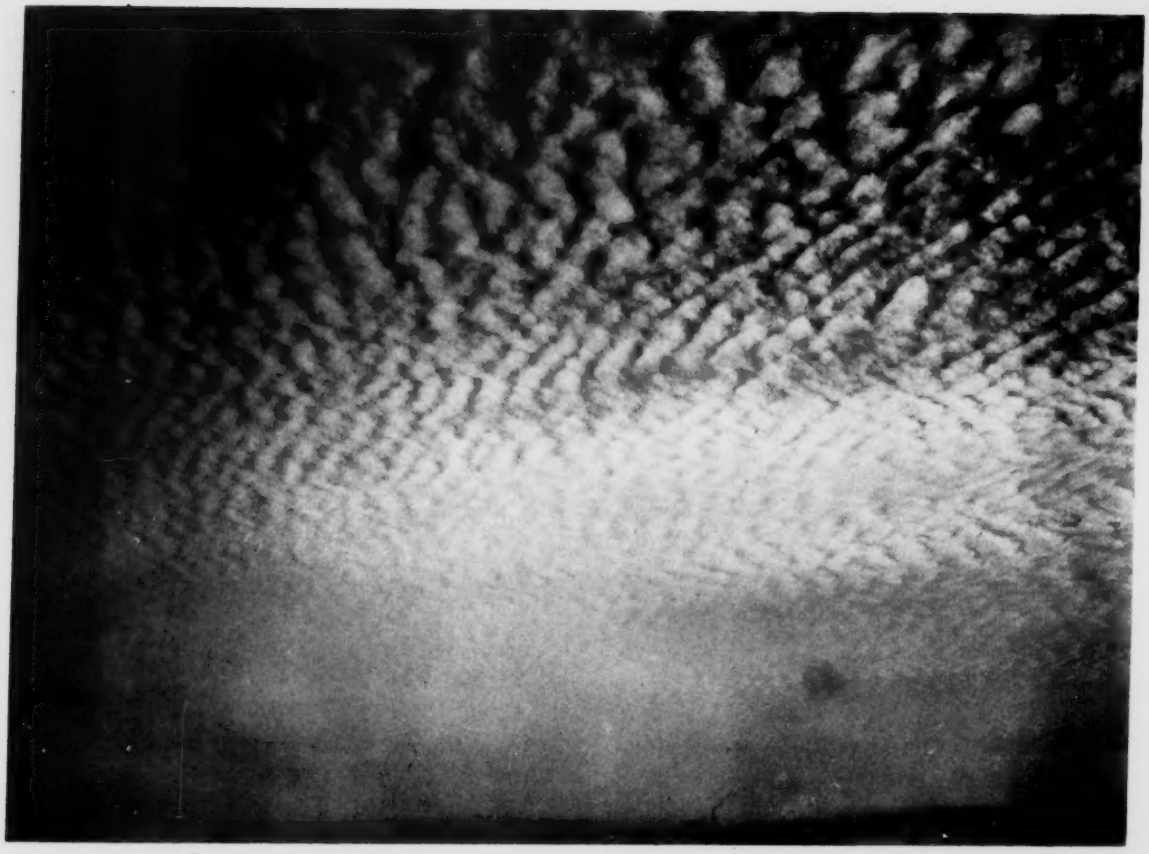

PHOTOGRAPHS OF CLOUDS. TAKEN AT THE SYDNEY OBSERVATORY, NEW SOUTH WALES.

By H. C. Russell, F.R.S.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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of our weather studies—ordinary Marian (not isochromatic) plates being used."

Somewhat similar photographs of clouds have during the past few years been taken by M. A. Angot in France and by Padre Denza at the Vatican Observatory in Rome. A very fine series of reproductions of Padre Denza's photographs have been published in the third volume of the *Specola Vaticana*, showing that a beginning has already been made towards the accurate study of cloud formation and the velocity of wind currents in the upper air. The great layers of stratus cloud seem to present some analogy of structure to the cloud forms seen in the solar photosphere, though the conditions of cloud formation must be very different on the sun and in our upper air.

Our layers of stratus cloud seem to be formed at the junction of layers or strata of air of different temperatures moving with different velocities; they frequently exhibit a regular series of billows extending over a large area of the horizon. It has been found by laboratory experiments that when air is perfectly free from particles of dust, it may become supersaturated with moisture, but when fine particles are introduced there is a sudden precipitation of fog. A stream of air may not only differ from the surrounding air in temperature and velocity, but it may differ in the amount of dust which it carries, as well as in its electrical condition. We, however, at present know but little of the conditions affecting the precipitation of water vapour into fog, and of the still more rapid precipitation into rain which takes place during a cloud-burst. Such photographs may enable us to study these conditions as well as the velocity of air currents at different altitudes.

To the eye, the blue sky between masses of cloud looks darker than the cloud patches, but with ordinary photographic plates, which are sensitive to the blue and violet rays, there is frequently very little difference in the actinic quality of the light derived from white clouds and their blue background. Many methods have been suggested to avoid this difficulty, such as the use of coloured glass screens before the camera, and the use of isochromatic and other plates sensitive at the red end of the spectrum. Prof. Riggenbach has suggested another method of cloud photography, which depends upon the fact that the light from blue sky is generally partially polarized, while that from white clouds is much more feebly polarized. He proposes to use a Nicol's prism or other analyzer in front of the lens of the camera, so as to cut down the polarized light and increase the contrast between the brightness of the clouds and their background. One of the objections to this method is that the light of the sky is very differently polarized in different directions, the polarization depending upon the direction in which the light of the sun falls upon the dust suspended in the air. But it will be seen from Mr. Russell's photographs that by giving suitable exposures, and careful development, very good results can be obtained, without using either isochromatic plates or a polarized field.

Some of the most striking results are obtained when large clouds are passing before the sun so that their edges are brilliantly illuminated, and thus the edges of the clouds produce a much stronger impression upon the photographic plate than the background of sky on which they are seen projected. There seems to be a very distinct and easily recognizable difference between the forms of cumulus cloud seen in the winter and in the summer seasons, and, according to Mr. Russell, there is even a characteristic difference between the clouds which form in Australian and in European air. Such little characteristic differences are well worthy of study, not only by artists, but by students of science.

Notices of Books.

A Selection of Photographs of Stars, Star Clusters and Nebulæ. By Isaac Roberts, D.Sc., F.R.S. (London: Universal Press, 326, High Holborn. 1894.) Dr. Roberts has made a most handsome present to the astronomical world by the publication of this series of fifty-one quarto reproductions of astronomical photographs, taken with his twenty-inch silver-on-glass reflector. The volume forms by far the most valuable atlas of astronomical photography which has yet been published. In the introduction Dr. Roberts gives an account of some of the difficulties which have been encountered in keeping the mirror accurately fixed upon the objects photographed as they are carried round in the heavens by the earth's rotation, and of the methods which have been devised by himself and by Sir Howard Grubb for overcoming these difficulties. It is impossible to firmly fix the speculum of a reflecting telescope in its cell. If the speculum is tightly gripped it is distorted and the definition is spoilt; consequently a little play must always be allowed, and in the course of exposures lasting for several hours, as the position of the telescope materially changes with respect to the horizon, the speculum tends to shift in the telescope tube. These shifts have to be carefully watched for and guarded against, for if the clock motion were ever so accurate they would produce an apparent shift of the star images on the sensitive plate. Dr. Roberts' method of detecting such small shiftings of position of the mirror is to make use of a small telescope directed through a hole pierced at the centre of the mirror and its cell, towards a silvered plane fixed to the slide which carries the sensitive plate. The image of a star can thus be brought to the centre of cross wires in the little collimating telescope, and any shift of the speculum relative to the sensitive plate can be detected and allowed for. The equable driving of his clock motion is also controlled by a refractor of seven inches aperture mounted on the declination axis which carries the reflecting telescope. Very good photographs of the interior and exterior of Dr. Roberts' observatory at Crowborough are given, which will no doubt add to the interest of the volume to the general public who are not familiar with observatory details. It is impossible in a short notice adequately to refer to the magnificent series of astronomical photographs contained in this volume. The reproductions of Dr. Roberts' classical photographs of the great Andromeda nebula and of the Orion nebula are excellent, but the chief interest of the volume lies in the number of photographs of comparatively small nebulæ and clusters which are here published for the first time.

Biological Lectures and Addresses. Delivered by the late Arthur Milnes Marshall, M.A., M.D., D.Sc., F.R.S., Prof. of Zoology in Owens College. Edited by C. F. Marshall, M.D., B.Sc. (London: David Nutt, 1894.)—The majority of the lectures and addresses collected in this volume have already been printed, but some of them, which have been buried in the Transactions of local learned societies, have not been generally accessible. Prof. Marshall's brother has very carefully edited the lectures, amplifying, where it was necessary, such of the lectures and addresses as only existed in manuscript. The lecture on the influence of environment on the structure and habits of animals, as well as the presidential address on "Inheritance," delivered to the Manchester Microscopical Society in 1888, may be especially recommended.

The following books have been received for review:—

Elementary Mechanics. Stage III. By J. C. Horobin, M.A. (G. Bell & Sons.)

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Tolstoi's Boyhood. Written by himself. Translated by Constantine Popoff. Cheaper Edition. (Elliot Stock.)

The Country Month by Month—July. By J. A. Owen and Prof. G. S. Boulger, F.L.S., F.G.S. (Bliss, Sands & Foster.)

The Monist for July. (Chicago.)

Elementary Meteorology. By Wm. M. Davis. (Boston, Ginn & Co.; London, Ed. Arnold.)

Agricultural Zoology. By Dr. J. Ritzema Bos. With Introduction by Eleanor A. Ormerod, F.R.Met.S., F.R.M.S., &c. Translated by Prof. J. R. Ainsworth Davis, B.A., F.C.P. Illustrated. (Chapman & Hall, Limited.)

Practical Lessons in Physical Measurement. By Alfred Earl, M.A. (Macmillan & Co.)

Mountain, Moor and Loch. Illustrated by pen and pencil, among the Highlands of Scotland. (London : Sir Joseph Causton & Sons.)

The Royal Natural History. Part 9. (F. Warne & Co.)

A Laboratory Manual of Physics and Applied Electricity. Vol. I. By Ernest Merritt and Frederick J. Roberts. Two vols. Edited by Ed. L. Nichols. (Macmillan & Co.)

Science Notes.

How our early savage ancestors discovered that plants grow from seeds is difficult to imagine. Mr. Grant Allen suggests, in the *Fortnightly Review*, what is certainly a plausible explanation, and he has brought together many references to folk-lore and savage customs that make what at first sight seems a highly improbable supposition appear credible. He points out that seeds and fruits formed the staple food of the savage, and that the only way in which it seems possible that these could be accidentally sown by them was by their custom of placing food on the mounds of their dead by way of propitiatory sacrifice to the departed soul. These seeds so placed would germinate and flourish on the newly dug grave. The explanation of this unwonted plenty that would naturally offer itself to the savage would be that the dead man, pleased with their kindly thought, had returned them their gift a hundredfold, by endowing the ground with a marvellous fertility. The area of the grave would extend, but the idea of the agency of the dead man in procuring their harvest would remain ; and so it became customary to sacrifice a human victim yearly, and bury him in the cultivated spot. Here Mr. Grant Allen comes to facts, and instances the well-verified practices still existing among some savage races, of killing and planting one of their number in the field before sowing the seed. Several customs still in practice at sowing-time among the Hindoos, and even among the peasantry of Germany, France and England, are quoted, and are distinctly relics of this ancient rite.

The Khonds of Orissa, Mr. Fraser tells us in his *Golden Bough*, until quite recently, set apart special individuals, known as Meriahs, for victims to fertilize their sowing. These Meriahs intermarried and their children were brought up to the same profession. During their lifetime they were regarded as sacred, and treated with great affection and deference. At the sacrifice they were cut up and a shred of flesh was given to each cultivator, who buried it in the centre of his field with his back turned and without looking at it. In the Hartz Mountains there are the vestiges of a similar sacrifice at seed-time. A living man is carried through the village on a rough bier, dirges being sung during the procession, and on arriving at the fields he is lightly buried by being covered with straw. Instances of such associations of killing and immolation with the sowing of grain might be indefinitely multiplied.

We learn from a footnote in Dr. Schenk's new "Manual of Bacteriology" that there is a growing opinion that cancer is ascribable to the action of a gregarine. These singular corticate infusoria will be familiar to students who have brought a microscope to bear upon the tissues of an earthworm ; indeed, it would be hard to find a specimen not infested by some samples of this group of Protozoa. In the invertebrata, however, they do not appear to be fatal to life, or, indeed, to cause any very great inconvenience, and these recent researches of Drs. Rüffer and Walker invest the group with a sinister human interest it has not hitherto possessed.

There is a horrible suggestion about the experiments of Messner upon bullets *purposely infected with micro-organisms*. These were discharged at tin boxes filled with sterilized gelatine peptone, and the channels made by the shots were examined. It was found that in spite of the heat of the discharge, and the violence and briefness of the impact, cultivations of bacteria arose in the gelatine. In other cases, the boxes had wrapped around them flannel infected with various bacteria, and uninfected bullets were fired through flannel and gelatine. Growths of bacteria derived from this covering appeared in the gelatine. Happily, a purposely infected shot is already provided against by international compact, which forbids the use of poisonous and explosive bullets.

THE RAINFALL OF 1893.

By Frederick J. Brodie, F.R. Met. Soc.

THE phenomenal drought experienced in the central and southern parts of England during the spring and early summer of 1893 naturally left its mark upon the meteorological annals, the aggregate rainfall for the entire twelvemonths being upon the whole far less than the average. In many localities, however, and especially in the extreme south of England, where the spring drought was most intense, heavy falls of rain occurred in the months of July, October, and December, the effect being to modify somewhat materially the state of things existing in the earlier portion of the year. The areas of severe drought were in fact not always those of least annual rainfall, the driest regions of all being transferred from the southern to the midland counties.

A general idea of the rainfall conditions existing over the United Kingdom during the whole of last year is given in the accompanying map, which shows by various degrees of shading the percentage of the average quantity attained in different parts of the country. The map is based on observations made at the seventy-eight stations contained in the Weekly Weather Report of the Meteorological Office, the averages used for comparison being mainly those for the twenty-five years 1866-90.

To obtain a true estimate of the state of affairs shown by the map, it seems desirable that some knowledge should exist respecting the amplitude of variation between the rainfall of different years and the average for a long period, and with the object of throwing a little light on this subject the author has worked out in percentage form the deviation from the normal shown by the London records for each year of the past eighty. The observations employed are : (1) For the years 1813-72 the values given in the diagram of the "Rainfall of the London District,"

prepared by the late Mr. G. Dines, and published in the Quarterly Weather Report for 1873; and (2) For the

Rainfall over the United Kingdom in 1893.

Districts in which total rainfall was less than 70 % of average shown thus :—

Districts in which total rainfall was more than 70 % but less than 80 %, shown thus :—

Districts in which total rainfall was more than 80 % but less than 90 %, shown thus :—

Districts in which total rainfall was more than 90 % but less than average, shown thus :—

Districts in which total rainfall was more than average, shown thus :—

years 1873-92 the London observations in the Daily Weather Report. The average used for comparison is that for the entire eighty years. The various years have been grouped under the following nine headings :—

1. *Normal* years, or years with a total rainfall within 5 % of the average.
2. *Rather dry* years, or years with a total rainfall from 6 to 10 % *less* than the average.
3. *Dry* years, or years with a total rainfall from 11 to 20 % *less* than the average.
4. *Very dry* years, or years with a total rainfall from 21 to 30 % *less* than the average.
5. *Exceedingly dry* years, or years with a total rainfall more than 30 % *less* than the average.
6. *Rather wet* years, or years with a total rainfall from 6 to 10 % *more* than the average.
7. *Wet* years, or years with a total rainfall from 11 to 20 % *more* than the average.
8. *Very wet* years, or years with a total rainfall from 21 to 30 % *more* than the average.
9. *Exceedingly wet* years, or years with a total rainfall more than 30 % in excess of the average.

Applied to the London records for the long period in question, the above classification yields the following results. Of the eighty years—

19, or 1 in 4, were *normal*.

16, or 1 in 5, were *rather dry*.	6, or 1 in 13, were *rather wet*.
10, or 1 in 8, were *dry*.	10, or 1 in 8, were *wet*.
7, or 1 in 11, were *very dry*.	7, or 1 in 11, were *very wet*.
1, or 1 in 80, was *exceedingly dry*.	4, or 1 in 20, were *exceedingly wet*.

It will be seen that while the "dry" and "wet," and the "very dry" and "very wet" years were evenly balanced, the number of "rather dry" years was greatly in excess of the "rather wet" ones, the discrepancy being partially adjusted by the large preponderance of "exceedingly wet" over "exceedingly dry" years. The one exceedingly dry year occurred in 1884, when the total rainfall was only seventeen inches, or thirty-one per cent. less than the average. The four exceedingly wet years occurred in 1824, 1852, 1860, and 1872, the amounts being respectively thirty-two inches, thirty-five inches (forty-three per cent. more than the average), thirty-three inches, and thirty-two inches. Comparing the amounts recorded in 1852 and 1884, we gather that it is quite possible for the London rainfall in one year to amount to more than twice as much as that in another. It is, of course, very doubtful whether the limits of variation shown by the London records would apply to all other parts of the Kingdom, but so far as the eastern, central and southern counties of England are concerned the results doubtless supply a sufficiently fair idea of the probable amplitude of range to serve as a guide to the following remarks.

Turning, then, to the conditions shown in the map, and reviewing first of all the state of affairs existing in Scotland, we see that in the north of that country the rainfall was in excess of the average, the greatest divergence being shown at Wick and Glencarron, where the excess amounted to over twenty-five per cent. At the former station the fall was larger than in any year of the past twenty-eight. It is rather curious to observe that the year 1884, which, like 1893, was a very dry one in England, was also wet in the north of Scotland, a somewhat disquieting fact for those who believe in the effect of lunar or planetary influences upon our weather. In a narrow band stretching from east-north-east to west-south-west across the more central parts of Scotland the rainfall of last year was not more than ten per cent. short of the average, but in all the more southern parts of the country the deficiency amounted to at least fifteen per cent., and in some places to over twenty per cent. Out of nine stations situated in these districts, the driest was Ochtertyre, near Crieff, where the total fall was twenty-seven per cent. less than the normal. At another station, Marchmont, in Berwickshire, the percentage value was seventy-five, the amount being the smallest experienced for at least twenty-six years past.

The condition of affairs in Ireland is represented on the map by three bands, or zones, running diagonally from north-east to south-west across the country. In the westernmost band the rainfall amounted to more than ninety per cent. of the average, and at Malin Head it slightly exceeded the normal, as deduced from observations extending over the limited period of nine years. In the central zone the percentage was between eighty and ninety, while in the easternmost zone, including all the eastern and southern parts of the country, the amounts were less than eighty

per cent. of the average, the driest station of all being Waterford, where the value was as low as seventy per cent. At Valencia, where the total amounted to just three-fourths of the normal, 1893 was the driest year of the past twenty-eight.

Over England and Wales the distribution of rainfall last year was far less regular than in Scotland or Ireland, great variations being observed even in closely adjacent localities. Out of forty-four stations there was only one (Stonyhurst) at which the fall was in excess of the average, but at four others the deficiency was less than ten per cent., and when we mention that these were situated in such widely different parts of the country as Lancashire, Cambridge, Sussex, and Devonshire, the local character of many of last year's rains will at once be perceived. A general survey of the conditions shows that over a considerable portion of our northern and north-western counties, with some of the inland parts of our south-eastern districts, and including also Devonshire, Dorsetshire, and a portion of Somersetshire, the amount ranged between eighty and ninety per cent. of the average; so that in these localities the year may be regarded as a "dry" one. In all other parts of England the rainfall was less than eighty per cent. of the average (the year being, according to our definition, "very dry"), while in most of the central districts the amounts were under seventy per cent. of the average, the year being, therefore, "exceedingly dry." Of four stations situated within this latter area the driest of all were Stamford and Cirencester. At the former place the total rainfall was under seventeen inches, or about sixty-two per cent. of the average, while at the latter it was under twenty-one inches, or about sixty-three per cent. of the normal. In London the rainfall of last year amounted to a little over nineteen inches, or about seventy-seven per cent. of the average.

Comparing the rainfall of 1893 with records extending back in the majority of instances to the year 1866, it appears that, of the forty-four stations distributed over England and Wales, there were only six places in which last year came out the driest of the series. These were Alnwick Castle, Yarmouth, Geldeston, Stamford, Cirencester, and Holyhead. At a large number of the other stations 1887 was drier than 1893, the difference between the two years being in some places rather considerable, while in many portions of the country the weather was drier either in 1870 or in 1884, or in both years. Looking back over the London records since 1813, we find that there were five years with a smaller and one with an equally small amount of rainfall. The smaller aggregates were respectively 17·70 inches in 1847; 18·65 inches in 1854; 17·28 inches in 1858; 17·44 inches in 1864, and 17·04 inches (the smallest on record) in 1884. In 1850 the amount was 19·22 inches, or precisely the same as that recorded in 1893.

SOME PECULIARITIES OF WATER.

By J. J. STEWART, B.A.Cantab, B.Sc.Lond.

IT is a common saying that the greatest blessings we enjoy cost us nothing. This is especially true of those two main factors which produce health—fresh air and pure water. We can imagine the demand there would be for clear pure water, and the way in which it would be appreciated, if it was as rare and costly as wine. Not only is it lightly valued, but many intelligent people know very little about the nature of water. I propose, therefore, to say something about this well-known substance, which yet remains to many people so much unknown.

Water in many ways stands alone as perhaps the most singular of all substances studied by students of physics. To illustrate this, let us first consider the manner in which water behaves when it is heated. Take some ice-cold water—that is, water at the temperature of 0° Centigrade (or 32° on Fahrenheit's scale)—and gradually heat it up. It will be found that instead of expanding when it grows hotter, as nearly all solids and liquids do, it contracts; in other words, its density increases as the heat is applied, until its temperature rises to 4° C. It has now reached the temperature at which its density is greatest, and after this it begins to expand like an ordinary substance, slower at first and more quickly afterwards, till it reaches the temperature of 100° C. (or 212° F.), the boiling point of water; when, however much it is heated it grows no hotter, all the heat being used up in changing the water into steam, that is, in separating the molecules or minute particles of the liquid water to such a distance apart that it becomes a gas, and then exists as steam at the temperature of 100° C. As is well known, the heat required to turn one pound of water at 100° C. into steam at the same temperature is as much as is required to raise the temperature of five hundred and thirty-six pounds of water through 1° C.

This peculiarity of water, that it at first gets heavier when it is heated from the freezing point, makes a very great difference to the inhabitants of the earth, for if water conducted itself as other liquids, consider what would happen to lakes and sheets of water in winter. As the surface of the water was cooled down by contact with the frosty air the topmost layer would grow heavier and sink to the bottom, while its place would be supplied by warmer water from below, and this would go on till the whole of the water in the lake attained the freezing point, and then it would freeze from top to bottom, producing a great mass of ice which would take a long time to melt. What actually happens is as follows:—The water gets colder at the top and therefore heavier, and sinks till the temperature of 4° C. throughout the whole mass is arrived at. Then as the surface layers cool still further they become lighter than those below, and therefore do not sink but remain at the top till they fall to 0° C., or freezing point, and then change into solid ice. In this way a crust of immovable ice is formed on the top, while the water below it may be somewhat higher in temperature than the freezing point, and as ice is a bad conductor and it cannot sink downward the heat escapes but slowly from the water underneath, which is thus preserved from freezing. The result of all this is that we enjoy a temperate climate. If the lakes froze throughout, the fish would all be killed, and summer heat might scarcely suffice to melt the masses of ice which would remain at the bottom while only the surface water was warmed.

Most substances occupy a less space in the solid than in the liquid state; some, however, expand on solidifying, and water belongs to the second and smaller class. An obvious result of this is that ice floats on the top of water, and another result known to us all is, that when water freezes in a pipe the force with which it expands on changing to its solid condition is very apt to burst the pipe with effects which are often unpleasant on the arrival of the thaw. This expanding force is of extraordinary magnitude, and hollow bombs made of strong and thick metal have been burst by being first filled with water and then thrown out into the open air on a frosty day. When this was done, after a time the metal balls were heard to explode with a report like that of a gun, and the contents forced themselves out in the form of ice.

Substances which, like water, expand when they freeze

have their freezing point lowered by pressure. So water when exposed to great pressure freezes at a temperature below 0° C.—that is, it remains liquid even although it has fallen below the point at which in ordinary circumstances it turns solid. This lowering of the freezing point is but small, for an increase of pressure of one atmosphere—that is, about fourteen pounds on the square inch—the lowering is 0·0075° C., or roughly speaking, under the pressure of one ton weight per square inch ice melts at one degree Centigrade under its ordinary melting point. The pressure of one atmosphere—that is, the pressure of the air above us—is equal to the pressure of thirty-two feet of water; therefore at a depth of about thirty-two feet in the sea, or in a lake, the pressure is two atmospheres. Now at great depths in the sea the pressure at which the water there exists is much increased, and thus its freezing point is lowered. Besides this, the presence of the salts dissolved in sea water causes its freezing point to be lower.

The fact that the freezing point of water is lowered by pressure has an important bearing on the phenomena of glacier action. If a piece of wire be slung over a block of ice and weights suspended at the ends, it is found on looking at the ice after a time that the wire has penetrated into it, and if the block be left with the weighted wire pressing against it, in course of time the wire will be seen to have made its way completely through the ice. But the block will not be divided in two by this process; the ice closes together again behind the wire, and at the end remains as before, a solid block with perhaps a line of bubbles marking the course taken by the wire through it. This peculiar behaviour of the ice is called *regelation*, and may be explained by the lowering of the temperature of freezing produced by pressure. Under the wire there is an increased pressure so that the ice melts, but the water thus formed is below the freezing point, so that it at once becomes ice again behind the wire. Similarly broken pieces of ice near its melting point can be squeezed together in a press so as to form a solid block.

Effects like this occur in glaciers. Under pressure at certain points the ice is melted; thus water, occupying less bulk, is formed and the pressure at that particular point is relieved, being passed on to another portion of the mass. But the water formed, being lower in temperature than the surrounding ice, almost immediately resolidifies. Thus the ice behaves as if it had plasticity and was a viscous solid like wax.

It has also been suggested that ice does not melt suddenly at one particular temperature, but passes through an intermediate viscous state and that there is a continuous change of temperature from that of cold hard ice to liquid water; ice thus behaving like a substance such as paraffin wax, which gradually melts passing through a viscid condition, though in ice the change is much more rapid. If this is so, we can understand why two pieces of ice near the melting point when placed together should unite into one block even without pressure, for the hard ice would be at a lower temperature than the surface layer of water between the two pieces of ice, and the latter would therefore soon solidify.

This curious property of ice under pressure accounts for the readiness with which snowballs can be made by squeezing in the hands. When the snow is considerably below the freezing point the manufacture of snowballs becomes more difficult, and does not take place till the snow has been somewhat warmed by the hands.

Another peculiarity of water is that it is less compressible at high temperatures than at low. In winter it is more readily reduced in bulk than in summer. This is contrary to the behaviour of most liquids at ordinary temperatures, such as alcohol or ether, whose compressibility is increased by a rise of temperature.

In an account of the behaviour of water mention must be made of what is known as capillary phenomena. When the end of a tube, with a fine bore, is plunged beneath the surface in a basin of water, it is noticed that the water rises in the tube and stands at a higher level than that of the water surface in the basin. Also when water is sprinkled on a surface which it does not wet, such as velvet, it does not spread over the surface, but stands in isolated beads or drops. In fact, water behaves as if it was surrounded by a contractile skin, and a drop of water may be roughly compared to a fluid contained in an elastic india-rubber bag. This peculiarity in the surface layer of water is called superficial tension, and its amount may be measured by noting the height to which water rises in a tube of known diameter, for the tension round the circumference of the top of the column of water balances the weight of the water raised. It may be also measured by observations on the size of drops. It is explained by the different condition of the particles in the surface layer of the water, which on the side next the free air are not under the attraction of other water particles, and so differ from the particles in the midst of the water, which are surrounded on all sides by their neighbours and exposed equally all round to their attraction. It is owing to this surface tension that the pressure inside a soap bubble is greater than the pressure of the atmosphere outside. The velocity of small ripples on the surface of a smooth pond depends on the superficial tension, while the behaviour of large waves is controlled by gravity.

The passage of water along the pores of rocks is much facilitated by this capillary action, and has important consequences in the geological effects produced. Water is thus able to penetrate deep down through the crevices of rock, even against considerable pressure exerted against it by steam, and changes in the structure of the rocks are produced by the contained water when under pressure and raised in temperature in the interior of the earth's crust.

By application of great pressure the temperature of vaporization of water may be much raised, and this superheated water has been shown to have considerably augmented chemical activity, and to be able to dissolve and alter glass. The importance of this in the explanation of geological processes is obvious when we consider the great quantity of interstitial water contained in all the rocks of the earth's crust.

What the exact constitution of water or any other liquid is still remains very much a mystery. The molecules or particles of the liquid seem to be able to move about with considerable freedom, but when it becomes solid their position is much more fixed. Why water-stuff should occupy a greater space in the solid than in the liquid state no one has been able to explain. One peculiarity of water particles we can observe when we see them in the form of snow, and that is that they arrange themselves in crystals of the hexagonal system. This is well shown in the beautiful minute six-rayed stars of various shapes which are to be seen in freshly fallen snow.

Water boils when the pressure of its vapour produced by heating just exceeds the pressure of the external atmosphere. Thus the temperature at which boiling takes place depends on the atmospheric pressure, and, as is well known, is lower on the top of a mountain than at its base, so that cooking operations become more difficult at a high-lying place such as Quito on the Andes. Also from this cause the temperature of boiling water is less when the barometer is low. Thus we see that while the melting point of ice is lowered by pressure, the point of vaporiza-

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tion of water is *raised* by increasing the pressure. The law is that when a substance contracts on changing its state, as ice does on becoming water, the temperature at which the change occurs is lowered by pressure; when the change of state is accompanied by expansion, as when water becomes steam, the effect of pressure is to raise the temperature at which the change takes place. An interesting and readily performed experiment on the effect of pressure on the boiling point is the following:—Boil some water in a flask; while boiling is going on cork the flask and remove the source of heat; when the glass vessel has somewhat cooled down, squeeze a sponge saturated with cold water over the flask, and boiling will be seen to recommence. This is owing to the fact that the sudden application of the cold water outside condenses the vapour above the hot water within and thus considerably reduces the pressure above it, so that bubbles of vapour can be again formed in the liquid and boiling is renewed.

Water consists of the two gases, oxygen and hydrogen, combined together, and it may be easily decomposed into its elements. If a current of electricity from a battery consisting of several voltaic cells be sent between two plates of platinum placed opposite each other in a vessel of water, bubbles of gas will be observed to rise from the plates while the current passes; these are produced by the splitting up of the water particles, and in course of time the whole of the water may be thus changed into its constituent gases. By collecting the gas given off at the plates in separate jars it is found that the gas set free at one plate consists of hydrogen, while that collected at the other plate is oxygen, and that the volume of the hydrogen is almost exactly double that of the oxygen. Thus water consists of two volumes of hydrogen combined with one volume of oxygen, and if the combination takes place at a temperature above the boiling point of water it is found that the volume of steam produced is two-thirds that of the united volumes of the two gases. By placing hydrogen and oxygen gases together in a jar in the proportion by volume of two to one and then bringing the mouth of the jar to a flame a loud explosion occurs; the gases have combined together, and the sides of the vessel are seen to be covered with a dew of condensed drops of water.

THE ORIGIN OF THE GOLD OF QUARTZ VEINS.

By Prof. J. LOGAN LOBLEY, F.G.S., &c.

NOT more than thirty years ago the hypothesis of the igneous origin of the "vein stuff" of mineral veins was stoutly advocated by eminent geologists, and yet to-day the theory, so far as regards the earthy minerals of a vein, may almost be considered to be obsolete. The gold of quartz veins, however, is still held by many to have been introduced into the interstices of the quartz by igneous action. There are others, again, who, while admitting the aqueous introduction of the gold into the veins, still maintain the theory of its earlier igneous uprise from the deep interior into the massive rocks containing the veins. Recent observations and discoveries by geologists and chemists have now, however, laid the foundations for a theory which attributes the gold of quartz veins not only to an aqueous conveyance to the veins, but to an aqueous origin also, since it makes the waters of the sea the source of the gold.

The opinion of Sir Roderick Murchison, that auriferous veins were confined to Palæozoic rocks or the neighbourhood of igneous eruptions, has been contradicted by the finding of gold-bearing quartz veins in California traversing Cretaceous and Tertiary strata, even in localities where there are no indications of igneous action having taken place either in Cretaceous or Tertiary times. This goes far to displace the igneous hypothesis; but there is a fact of very great significance in this controversy which seems to have been strangely overlooked by the disputants. It is the remarkable absence of gold from volcanic products.

If gold was originally derived from plutonic sources, it ought to be found among volcanic products which come from the same deep-seated sources, and only differ from plutonic rocks in having been solidified under different conditions. But, although a most widely distributed metal, gold is almost if not quite unknown as a volcanic product. That quartz veins and metalliferous lodes containing the precious metal occur in some regions that have been subjected to volcanic action is true, but other regions of a still more pronounced volcanic character are non-auriferous. It is, too, a most important consideration that in gold-producing volcanic regions, the gold is rather in the veins traversing the non-volcanic rocks than in the volcanic rocks themselves. It may also be asked why is not gold a usual product of volcanic regions? So far, indeed, from volcanic districts being usually auriferous, the reverse is the case, for the usual non-association of gold with volcanic products is a conspicuous fact, and a much more remarkable and telling one than its mere statement suggests, both from the very wide distribution of gold and the richness of volcanic products in mineral species, metallic as well as non-metallic.

In the British Islands, gold was found in the non-volcanic districts of Sutherlandshire and the Lead Hills in Scotland, but not in the volcanic districts of Edinburgh, Skye, Mull, or Arran. In Wales, gold occurs at Barmouth and near Llandovery, but not at Cader Idris, Snowdon, or the Breidden Hills, where are volcanic rocks; and in England, gold has never been reported from the Clee Hills or the Wrekin, both volcanic, but from the valleys of Somersetshire and Devonshire. In Ireland, again, the gold districts of Wicklow, Londonderry, and Limerick are non-volcanic, while in volcanic Antrim and Kerry auriferous deposits are unknown.

But, to go further afield, the great volcanic island of Iceland is devoid of gold, as are also the eminently volcanic areas of Sicily, the Lipari and the Pouza Islands, as well as the several extinct volcanic districts of Italy. The great volcanic district of Auvergne in Central France, and the volcanic districts of the Eifel and the Siebengeberge, in Germany, are all non-auriferous; but we seek for gold with success in the bed of the Rhine that brings detritus from the non-volcanic Alps, and find it *in situ* in the non-volcanic rocks of Schemnitz, in Hungary, and the Abrudbanya, in Transylvania, while the volcanic trachytes of these districts are devoid of the precious metal.

Nor is the absence of gold from volcanic products only noticeable in the European part of the earth's surface. Quite on the other side of the globe, in the volcanic islands of the Pacific, gold is also conspicuous by its absence, but non-volcanic New South Wales and Queensland are richly auriferous; and although there is gold in the volcanic North Island of New Zealand, there is very much more in the non-volcanic South Island, while that in the North Island is not in volcanic rocks. The gold-fields of India are not amongst the volcanic rocks of the Deccan, but on the non-volcanic plains of Mysore, and the great auriferous regions of Northern Asia are in the Urals, and the central and eastern parts of Siberia, all non-volcanic. Western Africa, too, distant from the volcanic Cameroons, gives to the Gold Coast its auriferous sands, but from the altogether volcanic Canary Islands gold is not obtained.

But, certainly, the most striking example of the non-auriferous character of volcanic products has yet to be mentioned. The Vesuvian area of about one hundred square miles has produced by far the greatest variety of minerals of any area of even a hundred times its extent, no less than one hundred and twelve species being given in the descriptive catalogue in my "Mount Vesuvius" of 1888. These include a number of metallic minerals; but neither gold nor any salt of gold, or auriferous compound or alloy of any kind, has ever been noted, notwithstanding the diligent examination to which Vesuvian products have been subjected by competent observers for a long period of time.

The occurrence of rich auriferous detritus beneath masses of lava, both in California and in Victoria, has no bearing on the question, since these detrital deposits are not derived from the place where they now are, but from hills at a considerable distance, in which were the auriferous veins long before the outburst of the lavas now covering the beds that have resulted from the erosion of the rocks of which those elevations were formed. Indeed, in view of the wide dissemination of gold in the rocks of every continent, and its absence from so many widely separated volcanic regions, it would seem to be but a fair and reasonable conclusion that the gold of the surface rocks has not been derived from volcanic sources, and therefore not from the sources of plutonic rocks, and consequently not by igneous action.

The aqueous hypothesis of the occurrence of metallic gold in quartz veins is based on the following considerations:—Gold is one of the most insoluble and unchanging of minerals, whether metallic or non-metallic. It is not oxidized by either air or water, and is not attacked by any of the ordinary acids, much less is it dissolved by water either cold or hot. But it chemically unites with some, though very few, elements and so forms auric compounds, and these compounds are soluble to a greater or less extent in water, and it is itself soluble in selenic acid and also in aqua-regia or nitro-hydrochloric acid under certain conditions. Chlorine is one of the few elements with which gold forms a chemical compound, and this salt of gold, the auric chloride, or the terchloride of gold, is readily dissolved by water at ordinary temperatures. With sulphur a sulphide of gold is formed that is also a soluble salt, though not nearly so much so as is the chloride.

The long-continued unsuccessful efforts to crystallize carbon and alumina, though minute diamonds and rubies were eventually produced, sufficiently show that in Nature's laboratory conditions obtain that can only with the greatest difficulty be produced artificially. It seems probable that under natural conditions of heat and pressure gold will unite with silica, forming a silicate of gold slightly soluble in hot water. Thus the same conditions that favour the solution of silica itself, which, as is well known, is slightly soluble in hot water, and the deposition of it in cavities or fissures, would likewise be favourable to the formation of a silicate of gold in siliceous auriferous rocks, and the subsequent solution of the compound and its transportation also from the massive rock into any cavity or fissure. There would thus be an infilling of fissures with silica, together with an admixture of silicate of gold, not to mention other minerals. Time alone would then be required to effect the complete separation of the gold from the silica with which it was united, and leave it as free metallic gold in the diversified forms and quantities in which it is now found in quartz veins. In support of this view Bischoff, Dr. Sterry Hunt, and Prof. Newbery, all high authorities, have expressed the opinion that gold has probably been introduced into veins in the form of silicate.

The problem of the origin of gold, then, seems to be reduced to accounting for its occurrence in sufficient quantity in ordinary marine sedimentary rocks. As all the materials of these rocks were derived directly from the seas of the globe, it will be necessary to ask, in the first place, could the sea-water contain and deposit the gold now imbedded and disseminated in the rocks of the globe? This question can now be answered very distinctly in the affirmative.

Since the sea is the great receptacle for all solutions, it was safe to conclude that it contained the soluble salts of gold, but the fact is not now a matter of mere deduction, but of actual knowledge. Sonstadt found, from careful experiments on the sea-water of Ramsey Bay, Isle of Man, that sea-water contains a little under a grain of gold per ton. Estimating the whole of the gold production of the world to the present time at £8,500,000,000 sterling, and taking the weight of the sea-water of the globe at 560,000,000,000,000,000 tons, as was estimated by Prof. Wurtz, of New York, we find that the present seas of the globe contain upwards of 5,000,000 times as much gold as has ever been extracted from the rocks; and consequently we must conclude that the seas of the globe in the past have been fully able to stock its mineral deposits with all the gold they contain.

We now arrive at the next stage of the inquiry, which is, how can the gold be separated from its marine solution and be deposited along with the materials of the sands, the shales, the clays, and the limestones that constitute the sedimentary rocks?

By the accidental dropping of a piece of cork into a solution of chloride of gold, Mr. Richard Daintree, of the Geological Survey of Victoria, discovered that organic matter causes the decomposition of an auric chloride solution, and the consequent precipitation of metallic gold. During the deposition of the materials of the sedimentary rocks at the bottoms of the Palæozoic and Secondary and Tertiary seas, much organic matter undoubtedly existed on the sea bottom. Some strata are so crowded with the fossilized enduring parts of animal organisms, that they are now actually named, in geological nomenclature, "bone-beds" and "shell-beds," and we have abundant evidence of the existence also, through the geological periods, of a great amount of algæ or "sea-weed."

Assuming, then, that the waters of the seas of the past contained gold by the solution of its salts as our present sea-water does, the conditions would be quite favourable for the deposition of gold contemporaneously with the accumulation of the ocean bed. The amount of gold thus deposited would, however, necessarily be so exceedingly small, in proportion to the mass in which it was included, as to be almost infinitesimal, and too little, therefore, to be detected in the resulting rocks, unless concentrated by separation from the general mass and accumulation in aggregations conjointly with other metallic mineral matter.

Consequent upon the important discovery of Daintree, Prof. C. Wilkinson carried out a long series of experiments, from which it was evident that gold precipitated by organic matter aggregated around metallic nuclei, and that besides gold itself, the sulphides of the metals, as pyrites and galena, were especially attractive. This is in entire accordance with the well-known fact of the association of gold with the metallic sulphides, and particularly with pyrites. When in association with pyrites or other metallic minerals, whether an association of adhesion merely or as an alloy, the gold would remain so associated until induced by the occurrence of new and favouring conditions to sever itself from its metallic associates, and

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chemically combine with an element or a compound for which under the conditions to which it was exposed it had affinity, and which body I imagine would be supplied by silica.

From these considerations it seems probable that gold was originally dissolved in the waters of the ocean, from which it was deposited, as the result of the decomposition of soluble salts of gold by the action of organic matter, and that it was then eliminated from sedimentary rocks by segregation to other metallic matter with which it remained associated until thermal conditions (caused by deep-seated position or not far distant igneous action) induced a chemical reaction, and likewise heated sufficiently the subterranean water of the rocks to make it an effective solvent of the auriferous compound. So the gold of the massive rocks was carried with silica by percolating water into the accumulating "vein-stuff" of rock-fissures, where on cooler conditions supervening, the auriferous compound was deposited in a solid condition, and the gold itself subsequently separated, by the segregation of the silica to the vein quartz, and left disseminated through the vein-stuff as metallic gold in the forms in which it is now found.

THE FACE OF THE SKY FOR AUGUST.

By HERBERT SADLER, F.R.A.S.

SPOTS and faculæ are still conspicuous objects on the solar disc. Conveniently observable minima of Algol occur at 11h. 45m. P.M. on the 13th, and at 8h. 34m. P.M. on the 16th.

Mercury is a morning star in August, and is favourably placed for observation during the first three weeks of the month. He rises on the 1st at 3h. 20m. A.M., or 1h. 5m. before the Sun, with a northern declination of 18° 15′, and an apparent diameter of 9″, nearly $\frac{9}{10}$ths of the disc being illuminated. On the 5th he rises at 3h. 5m. A.M., or 1h. 26m. before the Sun, with a northern declination of 19° 0′, and an apparent diameter of $8\frac{1}{4}$″, $\frac{27}{100}$ths of the disc being illuminated. He is at his greatest western elongation (18° 56′) on the 9th. On the 10th he rises at 2h. 59m. A.M., or 1h. 41m. before the Sun, with a northern declination of 19° 25′, and an apparent diameter of 7″, $\frac{43}{100}$ths of the disc being illuminated. On the 15th he rises at 3h. 8m. A.M., or 1h. 38m. before the Sun, with a northern declination of 18° 56′, and an apparent diameter of $6\frac{1}{4}$″, $\frac{63}{100}$ths of the disc being illuminated, and the planet now approaching his greatest brightness. On the 20th he rises at 3h. 34m. A.M., or 1h. 20m. before the Sun, with a northern declination of 17° 43′, and an apparent diameter of $5\frac{1}{2}$″, rather more than $\frac{8}{10}$ths of the disc being illuminated. On the 25th he rises at 4h. 7m. A.M., or 1h. 5m. before the Sun, with a northern declination of 14° 38′, and an apparent diameter of $5\frac{1}{4}$″, $\frac{94}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to permit of his being observed. While visible he describes a direct path from the confines of Gemini, through Cancer into Leo, being near δ Cancri on the 16th, and Regulus on the 27th.

Venus is a morning star, but is fast becoming a very uninteresting object for the amateur. She rises on the 1st at 1h. 48m. A.M., with a northern declination of 22° 28′, and an apparent diameter of 12″, $\frac{76}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on February 7th. On the 13th she rises at 2h. 8m. A.M., with a northern declination of 21° 15′, and an apparent diameter of $11\frac{1}{2}$″, $\frac{8}{10}$ths of the disc being illuminated. On the 20th she rises at 2h. 27m. A.M., with a northern declination of 19° 51′, and an apparent diameter of $11\frac{1}{4}$″, $\frac{82}{100}$ths of the disc being illuminated. On the 31st she rises at 2h. 57m. A.M., with a northern declination of 16° 45′, and an apparent diameter of $10\frac{3}{4}$″, $\frac{92}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about what it was on February 8th. During August, Venus pursues a direct path through part of Gemini and the whole of Cancer, ending on the confines of Leo and Cancer, being very near δ Cancri on the 7th.

Mars is an evening star, rising on the 1st at 10h. 14m. P.M., with a northern declination of 5° 38′, and an apparent diameter of 13·5″, the phase on the preceding limb amounting to about 2″. On the 9th he rises at 9h. 50m. P.M., with a northern declination of 6° 51′, and an apparent diameter of 14·4″. On the 19th he rises at 9h. 19m. P.M., with a northern declination of 8° 6′, and an apparent diameter of 15·6″. On the 31st he rises at 8h. 38m. P.M., with a northern declination of 9° 11′, and an apparent diameter of 17·2″, the phase on the *s p* limb amounting to 1·7″. During August, Mars pursues a direct path through Aries, starting from the confines of Pisces, but without approaching any naked eye star very closely.

Jupiter is an evening star in the sense of rising before midnight at the end of the month. On the 1st he rises at 0h. 53m. A.M., with a northern declination of 23° 1′, and an apparent equatorial diameter of 33″. He rises on the 18th at 11h. 56m. P.M., with a northern declination of 23° 4′, and an apparent equatorial diameter of $34\frac{1}{2}$″. On the 31st he rises at 11h. 14m. P.M., with a northern declination of 23° 4′, and an apparent equatorial diameter of 36·0″. The following phenomena of the satellites are visible while the Sun is 8° below and Jupiter 8° above the horizon:—At 3h. 4m. A.M. on the 3rd a transit ingress of the second satellite. At 3h. 4m. 43s. A.M. on the 10th an eclipse disappearance of the first satellite, and a transit ingress of the shadow of the second satellite at 3h. 44m. A.M. On the 11th a transit egress of the shadow of the first satellite at 2h. 32m. A.M., and of the satellite itself at 3h. 34m. A.M. On the 12th an occultation reappearance of the second satellite at 3h. 5m. A.M. On the 14th a transit egress of the third satellite at 2h. 22m. A.M. On the 18th a transit ingress of the shadow of the first satellite at 2h. 11m. A.M., and of the satellite itself at 3h. 18m. A.M. On the 19th an eclipse disappearance of the second satellite at 1h. 5m. 10s. A.M., and an occultation reappearance of the first satellite at 2h. 46m. A.M. On the 21st a transit egress of the shadow of the first satellite at 1h. 59m. P.M., and a transit ingress of the satellite itself at 4h. 2m. A.M. On the 25th a transit ingress of the shadow of the first satellite at 4h. 6m. A.M. On the 26th an eclipse disappearance of the first satellite at 1h. 20m. 2s. A.M., and an eclipse disappearance of the second satellite at 3h. 41m. 53s. A.M. On the 27th a transit egress of the shadow of the first satellite at 0h. 49m. A.M., and a transit egress of the satellite itself at 2h. 1m. A.M. On the 28th a transit ingress of the second satellite at 0h. 35m. A.M., a transit egress of its shadow at 0h. 40m. A.M., a transit egress of the satellite at 3h. 8m. A.M., and a transit ingress of the shadow of the third satellite at 3h. 29m. A.M. Jupiter pursues a direct path from Taurus into Gemini, being about $\frac{1}{2}$° north of η Geminorum on the 31st.

Both Saturn and Neptune are, for the observer's purposes, invisible.

Uranus is still an evening star, but should be looked for as soon after sunset as possible. On the 1st he sets at 10h. 46m. P.M., with a southern declination of 14° 53′, and an apparent diameter of 3·6″. On the 31st he sets at

9h. 18m. P.M., with a southern declination of 15° 6′. He describes a very short direct path in Libra during August, being in quadrature with the Sun on the 3rd. A map of the stars near his path will be found in the *English Mechanic* for March 23rd.

This month is one of the most favourable ones in which to observe shooting stars. The most noted shower is that of the *Perseids*, with a radiant point at the maximum display on August 10th in R.A. 11h. 52m. +56°. Observations of this region of the heavens with an opera-glass will no doubt show stationary meteors, or meteors which shift their positions very slowly. Their places, and the direction of their shift, should be noted for the purposes of determining whether the radiant is a geometrical point or a circle, or an elliptic area, as suggested with regard to the November meteors. (*Monthly Notices of the Royal Astronomical Society*, Vol. XLVII., pp. 66-73.) The radiant point souths at 5h. 37m. A.M.

The Moon is new at 0h. 24m. P.M. on the 1st; enters her first quarter at 10h. 5m. A.M. on the 8th; is full at 1h. 17m. P.M. on the 16th; enters her last quarter at 5h. 40m. A.M. on the 24th, and is new at 8h. 4m. P.M. on the 30th. She is in apogee at 7h. P.M. on the 13th (distance from the earth 252,340 miles), and is in perigee at 7h. A.M. on the 29th (distance from the earth 224,180 miles). At 0h. 59m. P.M. on the 6th the 1st magnitude star α (Spica) Virginis will disappear at an angle of 53° from the north point, and reappear at 1h. 19m. P.M. at an angle of 19°; and at 7h. 41m. P.M. the 6th magnitude star B.A.C. 4531 will disappear at an angle of 153°, and reappear at 8h. 38m. P.M. at an angle of 264°. At 8h. 6m. P.M. on the 9th the 5th magnitude star B.A.C. 5347 will disappear at an angle of 66°, and reappear at 9h. 10m. P.M. at an angle of 321°. At 3h. 5m. A.M. on the 19th the 6th magnitude star 20 Piscium will disappear at an angle of 98°, and reappear at 3h. 57m. A.M. at an angle of 187°; and at 10h. 6m. P.M. the 6th magnitude star 44 Piscium will disappear at an angle of 111°, and reappear at 10h. 45m. P.M. at an angle of 182°. At 0h. 5m. A.M. on the 24th the 5th magnitude star 23 Tauri (one of the Pleiades) will make a near approach to the lunar limb at an angle of 337°. At 1h. 2m. A.M. on the same morning the 4th magnitude star 27 Tauri (one of the Pleiades) will disappear at an angle of 9°, and reappear at 1h. 35m. A.M. at an angle of 302°, and at 1h. 22m. A.M. the 5½ magnitude star 28 Tauri (in the Pleiades) will make a near approach at an angle of 336°. At 1h. 4m. A.M. on the 26th the 5th magnitude star 136 Tauri will make a near approach at an angle of 171°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of July Problems (A. C. Challenger).

No. 1.—1. B to K5, and mates next move.
No. 2.—1. R to KKt5, and mates next move.

Correct Solutions of both the above have been received from H. S. Brandreth, Chat, G. G. Beazley, J. E. Gore, A Norseman, Alfred Allen, W. Willby, T. Guest, Alpha, E. W. Brook, J. M'Robert, J. Perkins.

No. 1 is correctly solved by H. A. Cookson.

Acknowledgment of correct solutions to June problems from T. Guest was accidentally omitted last month.

H. A. Cookson.—In No. 2, if 1. Q to KBsq, Black replies B × P.

Alpha.—The dual in No. 9 was almost as fatal as a second key, because the composer's main idea became no longer a necessary part of the problem.

W. Willby.—Could you not find a better key for the two-mover you send? The present key is trebly weak, because (1) it brings an inactive piece into play, (2) it shuts out the check of the Black Queen, (3) it guards one of the Black King's "flight" squares.

W. De Morgan.—Thanks for the conditional problems. We have written to you by post. "Semper" explains that he interpreted the condition in your last as referring only to the White pieces.

T. Guest.—Omission much regretted. You will see below that your guess is wide of the mark.

J. E. Gore and *F. H. Guest* are thanked for problems, which will be examined.

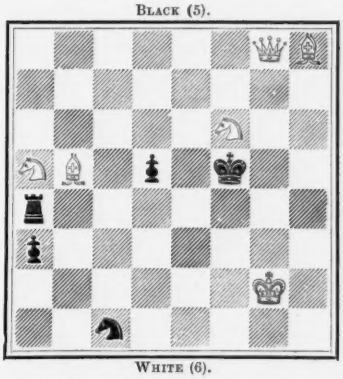
"KNOWLEDGE" PRIZE PROBLEMS.

First Prize.

(A. G. Fellows, Wolverhampton.)

"*Sweetness and Purity combined, &c.*"

Black (5).



White (6).

White mates in three moves.

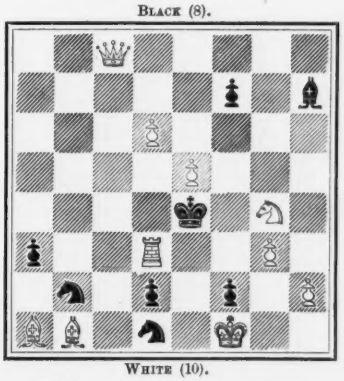
(*Key.*—B to K8.)

Second Prize.

(J. H. Christie, London.)

"*Fortes Fortuna juvat.*"

Black (8).

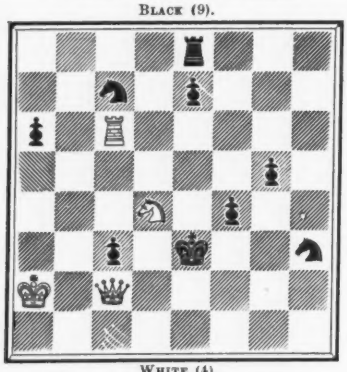


White (10).

White mates in three moves.

(*Key.*—B to R2.)

THIRD PRIZE.
(B. G. LAWS, London.)
"I can't help your troubles."
BLACK (9).



WHITE (4).
White mates in three moves.
(*Key.*—R to B5.)

We have much pleasure in appending Mr. Frankenstein's report. It will be seen that he is of opinion that the two duals in the first prize-winner are not of sufficient importance to displace it from its position. Mr. Frankenstein also agrees with one of our solvers that the P at R6, in the second prize-winner, should have been placed at R5, where it would have prevented the dual. The third prize-winner has an unavoidable dual. The remaining five placed problems are quite free from defects of this kind. The young composer should not infer from this curious coincidence that a dual is necessarily an advantage, or that two duals are better than one.

July 10th, 1894.

To the Chess Editor of KNOWLEDGE.

DEAR SIR,—I have carefully examined the eight problems which you forwarded to me to place in their order of merit, and I now have much pleasure in communicating to you the result of my labour.

1st, No. 3.—Certainly the most difficult problem in the tourney. It is a deceptive position, well-constructed and pleasing. Its purity is not conspicuous.

2nd, No. 18.—Decidedly clever, but less varied and difficult than No. 3.

3rd, No. 2.—A very good problem. It would have stood higher had more use been made of the White King.

4th, No. 4.—Very pretty; but the strategy seems very familiar to me, though I cannot recall a problem set just like this one. Key rather poor.

5th, No. 14.—Highly ingenious; but so soon as it is seen that 1. BKt4 will not answer, then the true key is easily found.

6th, No. 5.—A very fair problem, interesting but not difficult.

7th, No. 10.—This problem has one good variation after 1. P. QKt5. The remainder is commonplace, and economy faulty.

8th, No. 11.—A very unhappy position; more of a puzzle than a chess problem.

I hope your composers, solvers, and chess-readers generally will agree with my report. I have weighed the various positions with the greatest exactitude in my power, and I believe I have placed them in their true order of merit. Yours very truly, E. N. FRANKENSTEIN.

The final result of the Tourney is therefore as follows:
First Prize.—No. 3, by A. G. FELLOWS.
Second Prize.—No. 18, by J. H. CHRISTIE.
Third Prize.—No. 2, by B. G. LAWS.

The award will, as usual, remain open for one month.

Of the remaining selected problems, No. 4 is by H. Hosey Davis, No. 14 by Prof. G. B. Valle, No. 5 by R. G. Thomson, No. 10 by Mrs. Baird, and No. 11 by A. F. Mackenzie, most of whom, we think, have been accustomed to winning first prizes.

It may be interesting to compare the expert's award with the average opinion of the solvers who selected the eight problems to go before him. The result of their voting was:—No. 5, 44½ marks; No. 18, 37½; No. 11, 34½; No. 4, 33½; No. 3, 28; No. 14, 27½; No. 10, 26½; No. 2, 25½. It will be seen that one of the prize winners had a narrow escape of being excluded; this, however, may be accounted for by the fact that its composer abstained from voting. Two solvers placed it second. Only one solver placed No. 3 higher than fourth, but he placed it first; the others, no doubt, looked askance at the duals. No. 18 was the only problem on every list; but on three lists it occupied the last place. No. 4 found four admirers who placed it high. Nos. 5 and 10 secured two first places, while No. 11 was placed first by one solver and second by two.

CHESS INTELLIGENCE.

Mr. Lasker has accepted Mr. Steinitz's challenge to play a return match at Montreal and New York at the end of the year.

A match, which has been in progress for some time, between Mr. J. W. Showalter and Mr. A. B. Hodges, probably the two strongest amateurs in America, has just been concluded in favour of Mr. Hodges by five games to three, one game being drawn.

Mr. R. Loman has just defeated Mr. H. W. Trenchard in a match in which Mr. Trenchard had, at one time, a very decided lead. The final score was: Loman 7, Trenchard 4, drawn 2.

The Löwenthal Cup, or championship of the St. George's Chess Club, has been won this year by Mr. C. H. Chepmell just before his departure from England.

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